UNIVERSIDADE DE LISBOA

Lisbon School of Management and Economics (ISEG)

ACCESS TO HEALTHCARE IN PORTUGAL: ASSESSING GEOGRAPHICAL, ORGANIZATIONAL AND FINANCIAL BARRIERS

Autor: Francesca Fiorentino

Orientador: Prof. Doutor Miguel St. Aubyn

Tese especialmente elaborada para obtenção do grau de Doutor em Economia

2019

UNIVERSIDADE DE LISBOA

Lisbon School of Management and Economics (ISEG)

ACCESS TO HEALTHCARE IN PORTUGAL: ASSESSING GEOGRAPHICAL, ORGANIZATIONAL AND FINANCIAL BARRIERS

Autor: Francesca Fiorentino

Orientador: Prof. Doutor Miguel St. Aubyn

Tese especialmente elaborada para obtenção do grau de Doutor em Economia

COMPOSIÇÃO DO JÚRI

Presidente
Doutor Nuno João de Oliveira Valério, Professor Catedrático e presidente do Conselho Cientifico, Instituto Superior de Economia e Gestão da Universidade de Lisboa

Vogais
Doutor João António Catita Garcia Pereira, Professor Catedrático, Escola Nacional de Saúde Pública/Nova National School of Public Health da Universidade Nova de Lisboa

Doutor Miguel Pedro Brito St. Aubyn, Professor Catedrático, Instituto Superior de Economia e Gestão da Universidade de Lisboa

Doutor Miguel Rebordão de Almeida Gouveia, Professor Associado, Católica Lisbon School of Business and Economics da Universidade Católica Portuguesa

Doutora Isabel Maria Dias Proença, Professora Associada com agregação, Instituto Superior de Economia e Gestão da Universidade de Lisboa

2019

Index

ABSTRACT

Background: Healthcare is an important determinant of overall population health and the government may improve equity in health by improving access to healthcare.

Methods: Three different aspects of access to healthcare in the Portuguese setting were studied: 1) geographical barriers; 2) organizational barriers; and 3) financial barriers. Geographical accessibility was analysed in the context of hospital emergency units specialised for Acute Myocardial Infarction (AMI). We analysed the impact of distance between the patients' residence and the closest specialised hospital. The possible existence of organizational barriers was explored in terms of variation of in-hospital mortality or variation in treatment for AMI between weekdays and weekends. To assess the existence of financial barriers, we studied: 1) whether healthcare out-of-pocket payments (OOPP) in Portugal are exposing people to financial hardship; 2) the presence of unmet medical needs due to financial constraints; and 3) the determinants of OOPP.

Results: The distance between the patient and the closest AMI specialised emergency unit is not a predictor of higher in-hospital mortality for patients with AMI. Also being admitted on weekends or public holidays does not predict higher in-hospital mortality for AMI. We found that OOPP are regressive overall. Also, a significant proportion of households fall close to or below the relative poverty line after accounting for OOPP (13.8%, SE=0.003) and some households already below the poverty line still pay OOPP (15.6%, SE=0.004). Almost a third of individuals reported an unmet medical need. The proportion of unmet needs is higher for individuals living in poorer households. Finally, households with at least one sick member incur higher OOPP, *ceteris paribus*.

Conclusion: We found evidence supporting the existence of financial barriers to healthcare in Portugal, however in terms of the specific research questions, no evidence for the existence of organizational and geographical barriers was discovered.

Key words: Financial Barriers; Organizational Barriers; Geographical Barriers; Access to Healthcare; Equity in Health.

RESUMO

Introdução: Os cuidados de saúde são um importante determinante da saúde e o governo pode melhorar o respetivo acesso para alcançar maior igualdade dos níveis de saúde da população.

Métodos: Foram estudados três diferentes aspetos do acesso aos cuidados de saúde no contexto português: 1) barreiras geográficas; 2) barreiras organizacionais; e 3) barreiras financeiras. A acessibilidade geográfica foi estudada analisando as unidades de emergência especializadas do Enfarto Agudo do Miocárdio (EAM). Analisamos o impacto da distância entre a residência do paciente e o hospital especializado mais próximo. Exploramos a possível existência de barreiras organizacionais através da variação da mortalidade intra-hospitalar ou no tratamento do EAM entre dias da semana. Para avaliar a existência de barreiras financeiras, estudamos: 1) se os pagamentos diretos em saúde (PDS) colocam os agregados familiares (AF) em dificuldades financeiras; 2) a presença de necessidades médicas não satisfeitas (*unmet need*) por motivos económicos; e 3) os determinantes dos PDS.

Resultados: A distância entre o paciente e o hospital mais próximo com unidade de emergência especializada não é preditor de maior mortalidade intra-hospitalar para pacientes com EAM. Adicionalmente, ser admitido nos fins-de-semanas não prevê maior mortalidade intra-hospitalar por EAM. Encontramos que o PDS global sejam regressivo. Uma proporção significativa de AF encontra-se perto ou abaixo da linha de pobreza após os PDS (13,8%, SE=0,003) e alguns AF já abaixo da linha de pobreza incorrem em PDS (15,6%, SE=0,004). Quase um terço dos indivíduos que reportam uma necessidade médica reportou um *unmet need*, esta proporção é maior para indivíduos que vivem em AF mais desfavorecidos. Finalmente, AF com pelo menos um membro doente incorrem em PDS mais altos, *ceteris paribus*.

Conclusão: Foi encontrada evidência sobre a existência de barreiras financeiras e, nos limites das perguntas de investigação, não encontramos evidência de barreiras organizacionais e geográficas.

Palavras-chaves: Barreiras geográficas; Barreiras organizacionais; Barreiras financeiras; Acesso aos cuidados de saúde; Equidade em Saúde.

INTRUDUCTION

MOTIVATION

A main objective of a benevolent government is to enhance health equity across its population. Health is a very special good, being in some dimensions a public good (e.g. vaccination with herd effect), having potentially negative externalities (e.g. infectious disease) and being characterized by uncertainty (e.g. if and when disease may occur). Health is also special because, contrary to income where some degree of inequality may be desirable to create incentives for people to make more effort, there is no justification for allowing any inequality in health (Anad 2002). From another perspective, health is considered an investment good: individuals have an initial endowment of health which depreciates with time and on which they may invest time and money to preserve. It depends on many factors such as genes (or health endowments), odds, behaviors, environment and healthcare utilization (Grossman 1972). The definition of health itself is a broad definition with good health not being defined as the absence of sickness but as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."(WHO 2018a).

It should be clear that the government cannot distribute (good) health itself. It also follows, that a benevolent government may improve the health of its population by implementing a range of different policies, which may: 1) influence behavior such as smoking, drinking, sexual behavior, physical activity and healthy-diets; 2) ensure safety at work; 3) reduce environmental pollution; 4) increase health literacy; 5) enhance an inclusive society; 6) guarantee access to healthcare. Even more generally, as literature

suggests, richer and more equal countries usually are also healthier countries (Subramanian 2002), meaning that policies targeting income inequality are also expected to decrease inequity in health and increase population health. The objective of enhancing health equity presents many challenges namely: selecting the right mix of policies; ensuring financial sustainability; resolving potential conflicts with other fundamental principles such as individual freedom (e.g. compulsory vaccination); adapting to innovation and cultural changes and responding to public perceptions and beliefs.

Here we focus on policies targeting the provision of healthcare, a market associated to many failures such as externalities, asymmetric information, uncertainties and imperfectly competitive condition. The market failure, as well as the relevance of health, justifies the government intervention, which may become the main supplier of healthcare (in the National Health System) or may regulate the market more or less strictly (Poterba 1996).

Therefore policy makers should be highly interested in monitoring and assessing the status and trends of the population's health and access to healthcare in order to identify possible weaknesses, unmet needs as well as opportunities and best practices. The 2018 European Health report states that *"There are three key elements that, if designed well, interlink to provide the high quality and relevant evidence required to advance meaningful public health action. These are health information, health research and knowledge translation"* (WHO Regional Office 2018). In this context, research in applied health economics plays an important role. The present work limits its analysis to the government measure for enhancing (equal) access to healthcare. The analysis is carried on in the context of the Portuguese National Health System.

ACCESS TO HEALTHCARE

Healthcare is an important determinant of health and the government may improve access to healthcare to enhance health equality. So what is access to healthcare and how can it be improved?

The concept of access to healthcare may be simplified in two components: service availability and ease of utilization or "*degree of fit*" (Penchansky and Thomas 1981).

The service availability dimension mainly focuses on the supply side of healthcare and it may be measured, for instance, in terms of costs of access; waiting times; number of doctors or hospital beds per capita (geographic accessibility). In other words, availability of healthcare captures the potential of utilization. Some authors (Peters *et al.* 2008, Penchansky and Thomas 1981), conceptually separate the geographic dimension of access (geographical barriers) from the availability dimension of access.

The ease of utilization dimension is more comprehensive and takes into account the interaction between supply and demand, depending on different factors, usually defined as potential "barriers" to utilization (Millman 1993). Gulliford *et al.* (2002) resumes three potential sources of barriers: personal barriers, financial barriers and organizational barriers. Personal barriers include the personal beliefs (Mechanic, 1972), and individual perception of health and healthcare needs as well as cultural influences and the socio-economic context (e.g. neighborhood effect) (Wilson 1987). Financial barriers include the costs related to access, such as private direct payment (out-of-pocket payments) or the opportunity-cost related to the travel and waiting time. If too high, given the individual's capacity to pay, these costs may be a barrier to utilization. However these costs may also

be a useful tool for rationing utilization of healthcare services in the struggle to balance the right to access healthcare and financial sustainability. Finally, organizational barriers may arise because of the design of services or difficulties in understanding the healthcare system.

We have established that access to healthcare is a multi-dimensional concept which depends on both the supply and the demand for healthcare. But when may it be defined equal?

Defining equality of access is not a trivial task. Equity in access has two possible definitions: equal access for equal need (horizontal equity) or unequal access for unequal need (vertical equity). Horizontal equity in access to healthcare is often approximated in terms of equal utilization for equal need or in terms of "acceptable variation" of services (Oliver and Mossialos 2004). In these analyses, there is often an underlying assumption that need is uniformly distributed. For instance, a researcher may look into the geographical variation of waiting time for scheduling a breast cancer examination to verify whether it varies with location. Another example may be to investigate whether the probability to undertake a surgical procedure depends on the individual's race or religion (there is horizontal equity if race and religion are not significant predictors of probability to undertake a surgical procedure). Vertical equity is more difficult to study because its assessment usually implies ethical considerations such as defining (different) needs and defining which degree of unequal access or utilization should correspond to the different needs. Need for healthcare can be objectively measured in terms of higher disease severity or subjectively measured in terms of self-perceived health level. A possible research question could be: do premature newborns have more pediatric visits in their first year of

life compared to non-premature newborns? Or, given that breast cancer risk increases with age, do women older than 50 have more breast cancer screenings than younger women?

CONTRIBUTION TO THE LITERATURE

In this original work, three different aspects of access to healthcare will be studied: 1) geographical barriers (i.e. geographical accessibility); 2) organizational barriers; and 3) financial barriers. Analyses of these possible limitations to access are empirical, being restricted to specific barriers that may exist in the Portuguese context.

Geographical accessibility was analysed in the context of Acute Myocardial Infarction (AMI) specialised emergency units in Portugal (known as *via verde coronária*). The *via verde* is a coronary fast track system, operating 24/7, that was designed to offer rapid and high-quality treatment of patients admitted for AMI in emergency units of selected public hospitals. These specialised units were progressively introduced in Portugal since 2005. The present study explores the possible correlation between patients' distance from hospitals with *via verde* and in-hospital mortality for AMI. We used a database with individual data of all inpatient episodes occurring between 2011 and 2015 in public hospitals in a large Portuguese Region (Lisbon and Tagus Valley) (ACSS 2016). Patients' residence was used as a *proxy* for patients' location at the time of the episode and the travel time to the nearest *via verde* hospital was measured in minutes. We also considered the possible effect of the patient going first to a closer non-specialised (non *via verde)* hospital by introducing a dichotomous variable registering whether the closest hospital

was a specialised hospital or not. The regression model also controls for other confounders which may be predictors of the probability of surviving the AMI event: we controlled for age, sex and complexity of the episode among others.

This analysis provided some insights regarding horizontal equity in access to healthcare: whether patients with equal need have equal outcomes. If distance to the closest hospital with *via verde* is found to be a significant predictor of in-hospital mortality for AMI, the government should be interested in assessing the cost-effectiveness of improving access to the service, for instance by providing more hospitals with the service such that access to the system is more evenly distributed across the country. We believe that an equitable distribution of service across the territory should lead to time travelled not being a significant predictor of in-hospital mortality for AMI.

The possible existence of organizational barriers was explored in terms of variation of in-hospital mortality or variation in treatment for AMI between weekdays and weekends. Conceptually, there may be variation in outcomes because hospitals staffing levels are lower during weekends. The variation over time in the quality and supply of care may lead to lower health outcomes such as mortality. Acute disease such as AMI, for which prompt intervention is crucial, could be particularly sensitive to these variations. This phenomenon has become known as the 'weekend effect'. In the published article *"Does acute myocardial infarction kill more people on weekends? Analysis of in-hospital mortality rates for weekend admissions in Portugal"* my co-authors and I explored the possible existence of higher mortality rates for AMI patients admitted via the emergency room during weekends or public holidays in Portugal (Fiorentino *et al.* 2018).

Specifically, we were interested in whether being admitted during weekends or public holidays significantly predicts higher probability of death and lower probability of prompt

surgical intervention after controlling for a range of confounding mechanisms which may also influence mortality rates. In particular, we controlled for geographical variations in access to healthcare, episode complexity and individual patient characteristics. National data including all inpatient episodes occurring in public hospitals in mainland Portugal between 2011 and 2015 were used in the analysis (ACSS 2016). Similarly to the *via verde* study, this analysis focused on horizontal equity in the access to healthcare: whether patients with equal need have equal outcomes.

The last part of my contribution to the literature focuses on financial barriers to the access of healthcare. In particular, out-of-pocket payments (OOPP) in the Portuguese context were analysed. OOPP are defined as *"direct payments made by individuals to health care providers at the time of service use"* (WHO 2018b) and present serious concerns when they endanger users' financial protection. According to the WHO "*Financial protection is achieved when direct payments made to obtain health services do not expose people to financial hardship and do not threaten living standards*." (WHO 2018c). Portugal presents higher private financing of healthcare system than most of the European Union countries (OECD 2018), Although OOPP in the Portuguese National Health System (NHS) are usually low (lower than 25€ per contact with the system) and include many exceptions in terms of users' eligibility for co-payment.

The contribution in this dimension of access to healthcare was divided in two studies: financial protection and determinants of out-of-pocket payments.

The first study aimed to prove, using data from the last Portuguese Nationally Representative Health Survey (NRHS) and Portuguese Household Budget Survey (PHBS), that financial hardship exists and can be relevant also in countries with National

Health Systems. This study presents four analyses: 1) the descriptive analysis of OOPP in Portugal; 2) the characterization of unmet need for healthcare not satisfied due to financial constraints; 3) the concentration of OOPP by income group (concentration indexes and Kakwani indexes); and, 4) the occurrence of OOPP endangering the households' ability to pay (financial protection).

The second study aimed to explore the determinants of OOPP in Portugal in order to identify possible vulnerable groups. Here we used data from the 2014 NRHS which collected more health variables than the PHBS. We estimated three regressions using two-part models, where dependent variables are: 1) OOPP for visits, laboratory tests and other diagnostic and therapeutic procedures; 2) OOPP for medication; 3) OOPP for treatments. The variables which were considered for the inclusion in the analysis as independent variables were: geographic controls, demographic characteristics, citizenship, enrolment to voluntary health insurance or in health subsystems, health status of the representative or other member of the family, household and socio-economic characteristics.

The results of the two studies exploring potential financial barriers in the access to the Portuguese NHS, lead to some considerations regarding: 1) the unequal contribution of financing based on some "unfair criteria" (such as the presence of chronic conditions); 2) whether unmet medical needs are reported and relevant.

REFERENCES

Anad S. The concern for equity in health. J Epidemiol Community Health 2002;56:485–487.

Central Administration of Health System [Administração Central do Sistema de Saúde, ACSS, I.P], 2016.

Donabedian, A. Aspects of Medical Care Administration. Cambridge: Harvard University Press, 1973.

Fiorentino F, Ascenção R, Rosati N. Does acute myocardial infarction kill more people on weekends? Analysis of in-hospital mortality rates for weekend admissions in Portugal.

Grossman M. On the concept of health capital and the demand for health. J. Polit. Econ. 80(2), 223–255 (1972).

Gulliford M, Figueroa-Munoz J, Morgan M, Hughes D, Gibson B, Beech R, Hudson M. What does 'access to health care' mean? J Health Serv Res Policy. 2002 Jul;7(3):186-8.

Mechanic, D. Public Expectations and Health Care: Essays on the Changing Organization of Health Services. New York: Wiley, 1972.

Millman, M. (Ed.). (1993). Access to health care in America. Washington, DC: Institute of Medicine.

OCDE. Health Spending. https://data.oecd.org/healthres/health-spending.htm (2017). Accessed 22 January 2018.

Oliver A, Mossialos E. Equity of access to health care: outlining the foundations for action. J Epidemiol Community Health. 2004 Aug;58(8):655-8.

Penchansky R, Thomas JW. The concept of access: definition and relationship to consumer satisfaction. Med Care. 1981 Feb;19(2):127-40.

Peters DH, Garg A, Bloom G et al. 2008. Poverty and access to health care in developing countries. Annals of the New York Academy of Sciences 1136: 161–71.

Poterba JM. Government Intervention in the Markets for Education and Health Care: How and Why?'' In Victor R. Fuchs ed. Individual and Social Responsibility: Child Care, Education, Medical Care, and Long Term Care in America. Chicago: University Press of Chicago, 1996.

Subramanian SV, Belli P, Kawachi I. The macroeconomic determinants of health. Annu Rev Public Health. 2002;23:287-302.

Wilson WJ. The Truly Disadvantaged. Chicago, IL: The University of Chicago Press, 1987.

World Health Organization (WHO 2018a). Constitution of WHO: principles. http://www.who.int/about/mission/en/ Accessed 22 Jan 2018.

World Health Organization (WHO 2018b). Out-of-pocket payments, user fees and catastrophic expenditure. (2018) http://www.who.int/health_financing/topics/financial-protection/out-of-pocket-payments/en/ Accessed 22 Jan 2018.

World Health Organization (WHO 2018c). Health Financing-Financial Protection. (2018). http://www.who.int/health_financing/topics/financial-protection/en/ Accessed 22 Jan 2018.

World Health Organization (WHO) Regional Office for Europe. The 2018 European Health report. (2018) http://www.euro.who.int/en/data-and-evidence/european-health-report/european-health-report-2018. Accessed 22 Sept 2018.

CHAPTER ONE

ACUTE MYOCARDIAL INFARCTION SPECIALISED EMERGENCY UNITS IN PORTUGAL: A GEOGRAPHICAL APPROACH TO ASSESS THEIR IMPACT ON IN-HOSPITAL MORTALITY

ABSTRACT

Objective: To investigate whether hospital admissions for acute myocardial infarction (AMI) via emergency departments are characterised by a higher mortality rate when patients live further from hospitals with a specialised emergency unit [*via verde* (VV)], a fast track protocol in emergency departments of Portuguese National Health System hospitals.

Method. Patients aged 60+, residing in a major Portuguese region, admitted via an emergency department with a primary diagnosis of AMI (N=13,176). Pooled data from the National 2011-2015 Diagnostic-Related-Group database were analysed. Probit regression explores the association between the distance (in travel time) from the hospital with VV and in-hospital mortality, control variables were considered.

Results: In-hospital mortality was found to not significantly depend on the distance between patients' residence and the closest hospital with AMI-VV (p-value>5%).

Conclusions. Further research is needed to assess the impact of the specialised emergency units programme on health outcomes of the Portuguese population experiencing AMI.

Keywords: Acute Myocardial Infarction; accessibility; healthcare; Portugal; distance

INTRODUCTION

In 2005, in an effort to reduce stroke and acute myocardial infarction mortality (AMI), a *via verde* (VV) protocol was gradually introduced into Portuguese National Health System (NHS) hospitals. The programme featured a fast track protocol in emergency departments, operational 24 hours a day, 7 days a week, for stroke and acute myocardial infarction cases. The system was implemented in strategic hospitals and was distributed according to a principle of geographical equity across the territory. This work aims to study the *via verde coronaria* (AMI-VV). The fast track protocol may only be activated by citizens after calling the emergency number. The health professionals of the National Institute for Medical Emergencies [Instituto Nacional de Emergência Médica –INEM] arrive by ambulance and decide whether to activate the AMI-VV or not based on the echocardiogram results, as well as signals and symptoms of the patient. Data regarding the number of times the AMI-VV was activated contain an element of uncertainty due to the contradiction between official sources.

Based on hospital inquiries, the General Directorate of Health estimates that 33% of the patients admitted with Segment Elevation Myocardial Infarction (STEMI) accessed healthcare through AMI-VV in 2015, which corresponds to over 1,447 admissions through AMI-VV for patients with STEMI.(1) On the other hand, INEM, responsible for the decision of activating the AMI-VV, declared that in 2016 only 657 of AMI episodes were admitted through the fast track,(2) which represents approximately 6.1% of AMI emergency episodes.(3) The estimation of the proportion of AMI episodes admitted through the AMI-VV according to INEM coincides with the only official report on VV activity which was published in 2011. Both the INEM report and the official report state that in 2010, 6.0% of AMI episodes were admitted through AMI-VV (4). The low

proportion of AMI episodes admitted through the VV protocol may be explained by patients accessing healthcare with private transportation.

The decision to implement VV was political and was not supported by sound evidence: neither effectiveness nor costs were assessed. In 2012, Silva and Gouveia (5) attempted to capture the health gains associated with the *via verde* protocol for stroke in terms of reduction in ischemic stroke mortality. The authors found no evidence of reduced mortality. (5)

Internationally, there is a vast amount of literature outlining the relevance of distance on the quality of care. Nicholl *et al.* 2007 (6) found that in England, increased distance of the journey to hospital was associated with an increased risk of mortality; Avdic 2016 (7) showed that in Sweden there is a gradually declining probability of surviving an AMI per additional ten kilometres of distance from a hospital. Finally, Piette and Moose 1996, (8) showed the impact of distance on ambulatory care use, death and readmission of AMI patients and found significantly lower outcomes for patients living further from hospitals. Literature also suggests that an association between the neighbourhood status and the incidence of stroke exists. (9,10)

The data available do not allow for estimation of the costs associated with the programme's implementation; therefore a cost-effectiveness analysis, where the programme costs and benefits are compared to a counterfactual scenario where there is no AMI-VV, was not possible. The objective of the present study is to estimate whether a lower distance between patients' residence and the closest hospital with AMI-VV is associated with lower in-hospital mortality. We expect to find a positive or non-

significant relationship between in-hospital mortality and the distance between the patients' residence and an AMI-VV hospital.

METHODS

Data

A retrospective cohort study was conducted using the Portuguese national Diagnostic-Related-Group (DRG) databases. (3) These are datasets with administrative, clinical and individual level data regarding all inpatients discharged by NHS hospitals. The unit of analysis is the in-hospital episode. The dataset includes patients' demographic characteristics as well as their residence, diagnosis and procedure codes classified using the ninth version of International Classification of Diseases (ICD-9 CM). The database has no variable indicating whether the patient was admitted through AMI-VV or to a hospital with AMI-VV. The geographic unit of analysis is the *freguesia* (Local Administrative Unit [LAU] II), and we considered a five-year time horizon (2011-2015). The analysis was restricted to episodes concerning patients with residence in Lisbon and the Tagus Valley (LVT), one of the five health regions that constitute the National Health Service, wherein around 38% of Portuguese population lives [11]. In LVT we examined the 526 administrative units (*freguesias*) existing in 2011, with an average area of 22 km^2 each. The episodes occurring in hospitals not belonging to LVT or adjacent health regions (Center or Alentejo) were also excluded from the analysis since these episodes probably occurred in patients far from their residence. We included all episodes of patients admitted via emergency departments whose main diagnosis was AMI and identified the

episodes as being of patients admitted with STEMI or Non-STEMI (ICD-9 410.0-410.6/410.8-410.9 and 410.7, respectively).

Nevertheless, for the STEMI patients, prompt intervention is more crucial for increasing the odds of survival. (12) We excluded the episodes of patients less than 60 years old, once more, to reduce the probability of the patient being far from his/her residence at the time of the episode. We also considered the socioeconomic information available at the *freguesia* level. This information was collected in the 2011 Census (13) which is available online. The census includes demographic information, education by demographic group, employment rate by demographic group and housing conditions.

The official cartography of Portugal is made available by the General Directorate of Territory, (14) while the road network of the region was downloaded directly from the OpenStreetMap (OSM) archive. (15) This dataset was topologically corrected to enable network analysis operations.

Statistical Analysis

The distance between the mean centre of the *freguesia* (where the patient has residence) and the closest hospital with AMI-VV (either within LVT or outside) was measured in time of travel and computed using the network analysis tool, ArcMap 10.4.1. In order to estimate the time to travel (in minutes), we considered the regional road network and assumed the maximum legal speed per type of road (highway, city road etc.). The mean centre of the geographic unit of analysis (*freguesia*) was computed using ArcGIS Spatial Analysis Tools considering the population distribution of the territory, i.e. a dasymetric map. (16) The 2011 Census population was distributed within the administrative unit using the land use raster. (17) Land use territory classification was re-classified in four

classes: urban, semi-urban, low density and no population. We assumed that density for urban areas is double that of semi-urban areas which, in turn, is double that of low-density areas. Areas with no population had population density set at zero (See Supplementary material S1 for further details).

The remainder of the statistical analysis was performed using Stata14.0 statistical software.

A multiple regression was used to assess the association between in-hospital mortality and time of travel in minutes between the patient residence and the closest hospital with AMI-VV. The dependent variable is a dummy variable representing the mortality of a patient, which equals one if the patient has deceased and zero otherwise. Since the dependent variable is dichotomous, we assessed both a multiple logistic model and a multiple probit model and chose the best fit assessed using Akaike and Bayesian criteria. We also tested for spatial correlation of in-hospital mortality for AMI at the *freguesia* level using the Moran test. (18) This test was carried out in order to choose between a standard regression or a spatial regression. (19)

As previously introduced, we expect that most patients seeking healthcare use private transportation, while only a minority of patients (around 6%) called an ambulance and were efficiently admitted through the AMI-VV. (4,2) Patients using private transportation are more likely admitted to the nearest hospital, which, if not adequate, will eventually direct them to the nearest hospital with AMI-VV. For controlling this dynamic, we introduced a dichotomous variable (*hosp_vv*) indicating whether the closest hospital to the patient was designated AMI-VV or not. We expect that when the variable *hosp_vv* equals one, the probability of death decreases. Therefore, there are two independent variables of interest: the dichotomous variable registering whether the closest hospital is

an AMI-VV hospital or not and the distance (in minutes) to the closest hospital with AMI-VV.

The selection of other explanatory variables comes from a stepwise regression with backward elimination of non-significant confounders (considering a 5% significance level). (20) The inclusion of categorical variables (with 3 or more categories) was decided based on the F-statistic from one-way ANOVA tests, while continuous and dichotomous variable inclusion was based on their p-value (which is based on t-test). Regression variables adjusting for demographic characteristics such as age and gender were also tested with the expectation that older patients and men will present higher odds of death. Episode complexity is controlled for through the inclusion of a variable representing the episode severity (a categorical variable which classifies the episode using four complexity levels) and by considering the co-occurrence of a shock (ICD-9 CM 785.5).

Authors tested a dichotomous variable indicating whether the patient underwent a cardiac procedure such as Percutaneous Transluminal Coronary Angioplasty (PCI) (ICD-9 CM 00.66) and Coronary Angiography (ICD-9 CM 37.22/37.23). The interaction of this variable with the variable STEMI is also considered because we expect that the intervention is more relevant for STEMI cases than for non-STEMI cases.

Socio-economic conditions of the *freguesia* of residence were considered, namely the proportion of housing with running water, the rate of residents with higher education and unemployment rate. These variables may be predictors of higher socio-economic development and higher awareness of the relevance of promptness of intervention.

Finally, we test for any possible seasonality effect on mortality depending on the year, the week of the year or period of peak influenza in the emergency department. The peak

of influenza is captured by a dichotomous variable which takes the value of one in the weeks with peak incidences of influenza-like illness defined as more than 20 cases/100,000 inhabitants and zero otherwise [21-24]. Peak influenza periods may impact the functioning of the emergency department by creating an excess in the demand of health care in limited periods of the year. Emergency department congestion due to influenza is expected to have greater impacts on AMI non-STEMI episodes than on STEMI episodes. The authors identify two possible explanations: 1) non-STEMI episodes may have lower priority in emergency rooms compared to STEMI episodes, and 2) patients with a non-STEMI AMI are more likely to go to hospitals and use private transportation (consequently passing through the emergency room *triage*) instead of calling for emergency services or transportation.

RESULTS

The number of observations (i.e. episodes) included in the analysis, after applying the exclusion criteria, is 13,176 corresponding to 12,785 patients. The number of episodes per year varied between 2,463 and 2,726, the majority of episodes were non-STEMI episodes (7,742). A summary of variables is presented in Table 1.

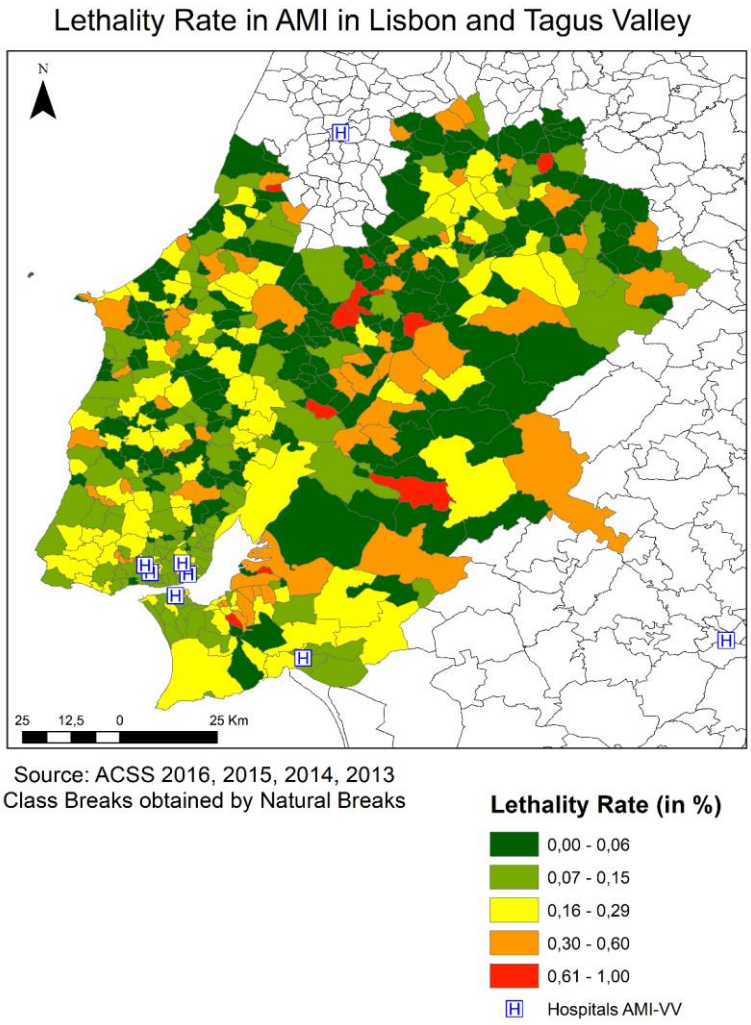
Table 1: Summary of database variables, pooled data 2011-2015.

Variables	**Mean/ Proportion**	**Standard Deviation**	**Minimum**	**Maximum**
Information available at the individual level				
Death	14.88%	0.36	0	1
Age	76.07	9.21	60	106
Female	44.33%	0.50	0	1
Time to closest AMI-VV (in minutes)	18.31	20.5	0.3	103
Closest hospital with AMI-VV	37.3%	0.48	0	1
Patients with surgery	51.76%	0.50	0	1
Shock	4.50%	0.21	0	1
Length of Stay	9.31	11.11	0	479
Health region				
Alentejo	0.19%			
Center	2.75%			
LTV	97.06%			
Severity Index				
Minor	28.81%			
Moderate	35.09%			
Major	29.66%			
Extreme	6.44%			
Information available at the *freguesia* level				
Population with Higher education	15.74%	0.09	1.11%	44.50%
Population Employed	42.21%	0.04	19.62%	59.62%
Population with children aged 15+	35.98%	0.03	24.63%	49.45%
Population aged 65+	20.00%	0.06	3.85%	41.59%
Population without literacy	3.53%	0.02	0.07%	19.34%
Population density (inhabit/km2)	31.75	297.61	0.001	3,879.33

LTV: Lisbon and Tagus Valley

The lethality rate of episodes (number of fatal episodes over total number of episodes) per *freguesia* (N=526) was on average 14.88% (95% confidence interval: 14.21%-15.53%). Lethality rates by geographic unit are presented in **Fig. 1**.

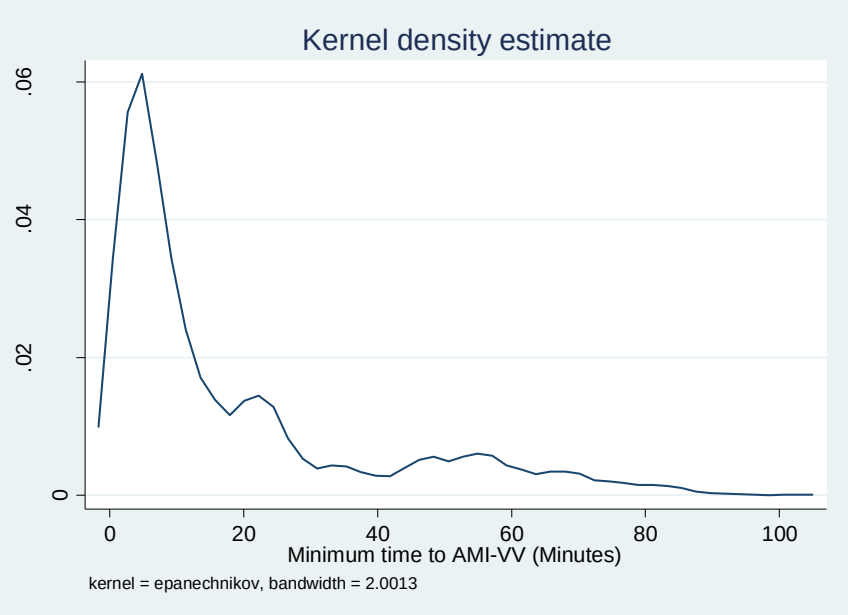
Fig. 1: Lethality rate of AMI episodes in Portugal, pooled data 2011-2015.



Visual evidence in Figure 1 suggests no spatial autocorrelation of lethality. This outcome was confirmed by the Moran test result which did not reject the null hypothesis of no spatial clustering. Therefore, standard regression was preferred to spatial regression. [19]

The mean and median time between the residence of the patient and the closest facility with AMI-VV was estimated at 18 (SD=20) and 9 minutes, respectively. The density distribution of the time to travel to the closest hospital with AMI-VV is represented in **Fig 2**.

Fig. 2 Kernel density estimate of time (in minutes) between patient residence and the closest Hospital with AMI-VV.



The Akaike and Bayesian criteria were higher in the logistic model compared to the probit model; therefore the latter was preferred.

Probit regression results are summarised in Table 2.

Table 2: Regressions Results (95% Confidence Interval)

Dependent Variable: Probability of Decease	coefficient	P-value	Lower limit (CI: 95%)	Upper limit (CI: 95%)
Female	-0.11	0.000	-0.17	-0.04
Age	0.01	0.000	0.01	0.02
Distance (minutes)	-0.001	0.261	-0.002	0.001
Closest Hospital AMI-VV	0.03	0.405	-0.043	0.11
Surgery and STEMI/Non-STEMI				
Not Surgery and Non-STEMI	Baseline			
Not Surgery and STEMI	0.75	0.000	0.68	0.84
Surgery and Non-STEMI	-0.60	0.000	-0.72	-0.49
Surgery and STEMI	-0.30	0.000	-0.40	-0.20
Shock	1.35	0.000	1.21	1.48
Severity Index				
Minor	Baseline			
Moderate	0.45	0.000	0.34	0.57
Major	0.89	0.000	0.77	1.02
Extreme	1.47	0.000	1.32	1.62
Influenza and Non-STEMI	0.14	0.011	0.03	0.25
Constant	-2.78	0.000	-3.10	-2.45
Pseudo R2	29.74%			

CI: Confidence Interval.

The dichotomous variable registering whether the closest hospital is an AMI-VV and the continuous variable *distance* which measures the distance in time to the closest hospital with AMI-VV are both non-significant at (5% significance level). Therefore, we found that the time of travel between the residence of the patient and the closest hospital with AMI-VV, and whether the closest hospital is AMI-VV or not, does not significantly predict higher in-hospital mortality. No significance was confirmed by the regression models excluding one of the variables of interest at the time (distance and "closest hospital AMI-VV"). We found that being younger and female lowers the likelihood of death, while patients with STEMI-AMI being hospitalised during an influenza peak had

a worse prognosis than those admitted off-peak. Also, the severity index was found to be a good predictor of in-hospital mortality. It is especially noteworthy that the peak influenza in the emergency department was the only seasonality effect which was found significant in predicting in-hospital mortality (only significant in STEMI sub-population). It follows that year dummies were not included as predictors in the regression because annual effect or trends were not found significant.

Socioeconomic variables, such as the proportion of the population employed, the proportion of people aged 65 or over, housing conditions etc. were found to be not significant, and were therefore excluded from the regression.

DISCUSSION

The study aimed to analyse the impact of AMI-VV on the probability of death following an AMI episode. We found that distance to the closest specialised hospital as well as the fact that the closest hospital is a specialised hospital does not significantly predict higher in-hospital mortality.

The non-significance of the coefficient of the variable *distance* may also reflect spatial equity in access to healthcare, i.e. the fact that hospitals with AMI-VV are strategically well-distributed in the region and patients often live close enough to an AMI-VV hospital. The decline of AMI mortality between 2013 and 2015 by 6.3% as well as the increase of primary angioplasty by 36.5% between 2011 and 2015, support this possible explanation. (24) Additionally, all socio-economic variables (at the *freguesia* level) were found not significant, reinforcing the hypothesis that AMI-VV are well distributed in the territory.

The non-significance of socio-economic status is in contradiction with previously published studies (25-27) which had access to data at the individual level. The difference in the result may be explained by the difference in setting and/or the quality of data used.

International literature assessing the relationship between AMI mortality and distance to the closest hospital is heterogeneous. In Japan, (28) USA (Los Angeles County (29) and Middle Tennessee (30)), Switzerland, (31) Scotland (Tayside) (32) and Italy (Sicily Region) (33) it was found that distance to the closest hospital is a significant predictor of mortality for AMI. Opposite results were obtained for other USA regions (Ohio (34) and California (35)), Japan (36) and England. (37) These results highly depend on the organisation of the healthcare system, the time and the quality of the data available.

This study has several limitations.

First, there was no information pertaining to whether the patient was admitted through the fast track or not. Therefore, the distance between patients' residence and the closest hospital with this service was used as a proxy of the AMI-VV effect. Second, the patients' location during the acute episode may be different from their residence. In order to mitigate this limitation, we decided to select only individuals aged 60 or over, hospitalised in facilities in LVT or adjacent health regions. Third, the results should be carefully interpreted because the number of AMI episodes admitted through the AMI-VV is still low compared to the overall number of AMI episodes in Portugal. The low rate of utilisation of the service may be explained by the fact that most patients access emergency units using private transportation instead of calling the emergency number. However, hospitals with AMI-VV are still expected to offer better healthcare to patients admitted with AMI compared to other hospitals, even if the patient was not formally admitted

through the AMI-VV. This factor is because hospitals with AMI-VV are expected to be comparatively more specialised in treating AMI episodes. Therefore we expected that patients living closer to AMI-VV or whose closest hospital was an AMI-VV had higher probability of surviving an AMI episode. Fourth, the only output considered in this study was the probability of death. Nevertheless, access to a faster track of care is also expected to impact the patients' quality of life. Prompt intervention should reduce the *sequelae* of the episode, i.e. reducing the probability of long-term disabilities.

Nevertheless, we had no access to the patient's health status after discharge. Finally, it should be noticed that this study was conducted using Portuguese national DRG databases which include administrative and clinical data. Given that this database was not built for research purposes, concerns can be raised regarding the quality of the data, namely the timestamp for each intervention. Nevertheless, the database used was still the best available at the time of this study.

CONCLUSIONS

We found no significant association between in-hospital mortality and the time of travel between patients' residence and the closest AMI-VV hospital, or whether or not the closest hospital had the AMI-VV protocol. Further research is needed to assess the impact of the *via verde* program on the health outcomes of the Portuguese population experiencing an AMI.

ACKNOWLEDGEMENTS

I thank Prof. Pedro Cabral, who supervised the realization of this work.

REFERENCES

1. General Directorate of Health [Direção-Geral da Saúde-DGS]. Doenças Cérebro-cardiovasculares em Números – 2015. Programa Nacional para as Doenças Cérebro-cardiovasculares. DGS Web site https://www.dgs.pt/em-destaque/portugal-doencas-cerebro-cardiovasculares-em-numeros-201511.aspx Published February 1st, 2016. Updated February 1st, 2016. Accessed December 30, 2017.

2. National Health System [Sistema National de Saúde –SNS]. Via verde coronária. NHS Web site https://www.sns.gov.pt/noticias/2017/02/15/via-verde-coronaria/ Published February 15th, 2017. Updated February 15th, 2017. Accessed October 1st, 2017.

3. Central Administration of Health System [Administração Central do Sistema de Saúde, ACSS, I.P]. 2016.

4. Ministry of Health [Ministerio da Saúde] 2011. Vias Verdes Coronária e do Acidente Vascular Cerebral Indicadores de Actividade 2010. Coordenação Nacional para as doenças cardiovasculares. June 2011, Portugal.

5. Silva S, Gouveia M. Programa Via verde do AVC: análise do impacto sobre a mortalidade do AVC. Revista Portuguesa de Saúde Pública. 2012: 172-179.

6. Nicholl J, West J, Goodacre S, Turner J. The relationship between distance to hospital and patient mortality in emergencies: an observational study. Emerg Med J. 2007;24(9):665-8.

7. Avdic D. Improving efficiency or impairing access? Health care consolidation and quality of care: Evidence from emergency hospital closures in Sweden. J Health Econ. 2016;48:44-60.

8. Piette JD, Moos RH. The influence of distance on ambulatory care use, death, and readmission following a myocardial infarction. Health Serv Res. 1996;31(5):573-91.

9. Lisabeth LD, Diez Roux AV, Escobar JD, Smith MA, Morgenstern LB. Neighborhood environment and risk of ischemic stroke: the brain attack surveillance in Corpus Christi (BASIC) Project Am J Epidemiol. 2007;165(3):279-87.

10. Diez Roux AV, Merkin SS, Arnett D, Chambless L, Massing M, Nieto FJ, Sorlie P, Szklo M, Tyroler HA, Watson RL. Neighborhood of residence and incidence of coronary heart disease. N Engl J Med. 2001;345(2):99-106.

11. Ministério da Saúde 2016. NHS Transparency Web site: http://transparencia.sns.gov.pt/explore/dataset/utentes-inscritos-em-cuidados-de-saude-primarios/?sort=tempo Published August 22nd, 2017. Updated August 22nd, 2017. Accessed February 2nd, 2018.

12. American College of Cardiology/American Heart Association Task Force on Practice Guidelines. ACC/AHA Guidelines for the Management of Patients with ST-Elevation Myocardial Infarction—Executive Summary. Circulation. 2004;110:588-636.

13. Statistics of Portugal (INE). Census Data. Statistics of Portugal Web site: http://cesos.ine.pt/xportal/xmain?xpgid=censos2011_apresentacao&xpid=CENSOS Published January 2013. Accessed November 20th, 2016.

14. General Directorate of Territory (DGT) 2011. DGT Web site: www.dgterritorio.pt/cartografia_e_geodesia/cartografia/carta_administrativa_oficial_de_portugal__caop_/caop__download_/ Accessed November 11th, 2016.

15. GEOFABRIK 2015. GEOFABRIK Web site: http://download.geofabrik.de/europe/portugal.html Published 2015. Updated February 3rd, 2018. Accessed November 11th, 2016.

16. Holt JB, Lu H. Dasymetric mapping for population and sociodemographic data redistribution, in Urban Remote Sensing: Monitoring, Synthesis and Modeling in the Urban Environment, ed. by , Yang X, ed, pp. 195–210, John Wiley & Sons, Ltd, Chichester;2011.

17. General Directorate of Territory (DGT) 2016. DGT Web site: http://www.dgterritorio.pt/cartografia_e_geodesia/cartografia/carta_administrativa_oficial_de_portugal__caop_/caop_em_vigor/ Published March 2nd, 2017. Updated March 2nd, 2017. Accessed November 11th, 2016.

18. Moran PAP. Notes on Continuous Stochastic Phenomena. Biometrika. 1950; 37 (1): 17–23.

19. Beale CM, Lennon JJ, Yearsley JM, Brewer MJ, Elston DA. Regression analysis of

spatial data. Ecol Lett. 2010 Feb;13(2):246-64.

20. Long, J. Scott (1997). Regression Models for Categorical and Limited Dependent Variables. Thousand Oaks, CA: Sage Publications.

20. Instituto Nacional de Saúde Doutor Ricardo Jorge. Boletim de Vigilância Epidemiológica da Gripe Relatório da Época 2010/2011. Accessed on may 2016, at http://www.insa.pt.

21. Instituto Nacional de Saúde Doutor Ricardo Jorge. Boletim de Vigilância Epidemiológica da Gripe Relatório da Época 2011/2012. Accessed on May 2016, at http://www.insa.pt.

22. Instituto Nacional de Saúde Doutor Ricardo Jorge. Boletim de Vigilância Epidemiológica da Gripe Relatório da Época 2012/2013. Accessed on May 2016, at http://www.insa.pt/.

23. Instituto Nacional de Saúde Doutor Ricardo Jorge. Boletim de Vigilância Epidemiológica da Gripe Relatório da Época 2013/2014. Accessed on May 2016, at http://www.insa.pt/.

24. Instituto Nacional de Saúde Doutor Ricardo Jorge. Boletim de Vigilância Epidemiológica da Gripe Relatório da Época 2014/2015. Accessed on May 2016, at http://www.insa.pt/.

24. General Directorate of Health [Direção-Geral da Saúde-DGS]. Programa Nacional para as Doenças Cérebro-Cardiovasculares – 2017. DGS Web site. https://www.dgs.pt/em-destaque/relatorio-do-programa-nacional-para-as-doencas-cerebro-cardiovasculares-2017.aspx Published March 1st, 2017. Updated March 1st, 2017. Accessed December 30, 2017.

25. Bucholz EM, Ma S, Normand SL, Krumholz HM. Race, Socioeconomic Status, and Life Expectancy After Acute Myocardial Infarction. Circulation. 2015 Oct 6;132(14):1338-46.

26. Donyavi T, Naieni KH, Nedjat S, Vahdaninia M, Najafi M, Montazeri A. Socioeconomic status and mortality after acute myocardial infarction: a study from Iran. Int J Equity Health. 2011 Feb 7;10:9.

27. Wang JY, Wang CY, Juang SY, Huang KY, Chou P, Chen CW, Lee CC. Low socioeconomic status increases short-term mortality of acute myocardial infarction despite universal health coverage. Int J Cardiol. 2014 Mar 1;172(1):82-7.

28. Murata A, Matsuda S. Association between ambulance distance to hospitals and mortality from acute diseases in Japan: national database analysis. J Public Health Manag Pract2013;19:E23–8.

29. Buchmueller TC, Jacobson M, Wold C. How far to the hospital? The effect of hospital closures on access to care. J Health Econ. 2006 Jul;25(4):740-61. Epub 2005 Dec 13.

30. Busingye D, Pedigo A, Odoi A. Temporal changes in geographic disparities in access to emergency heart attack and stroke care: are we any better today? Spat Spatiotemporal Epidemiol. 2011 Dec;2(4):247-63.

31. Berlin C, Panczak R, Hasler R, Zwahlen M; Swiss National Cohort Study Group. Do acute myocardial infarction and stroke mortality vary by distance to hospitals in Switzerland? Results from the Swiss National Cohort Study. BMJ Open. 2016 Nov 1;6(11):e013090.

32.Wei L, Lang CC, Sullivan FM, Boyle P, Wang J, Pringle SD, MacDonald TM. Impact on mortality following first acute myocardial infarction of distance between home and hospital: cohort study. Heart. 2008 Sep;94(9):1141-6.

33. Ferrante M, De Luca G, Fantaci G, Pollina Addario S, Scondotto S. [Distance from the nearest hospital and mortality for acute 39yocardial infarction (AMI) in Sicily Region (Southern Italy)]. Epidemiol Prev. 2014 Nov-Dec;38(6):373-8.

34. Yamashita T, Kunkel SR. The association between heart disease mortality and geographic access to hospitals: county level comparisons in Ohio, USA. Soc Sci Med 2010;70:1211–8.

35. Hsia RY, Kanzaria HK, Srebotnjak T, et al. Is emergency department closure resulting in increased distance to the nearest emergency department associated with increased inpatient mortality? Ann Emerg Med 2012;60:707–715.e4.

36. Matsui H, Fushimi K, Yasunaga H . Variation in risk-standardized mortality of stroke among hospitals in Japan. PLoSONE2015;10:e0139216.

37. Alexandrescu R, Bottle A, Jarman B Jarman B, Aylin P. Impact of transfer for angioplasty and distance on AMI in-hospital mortality. Acute Card Care 2012;14:5–12.

SUPPLEMENTARY MATERIAL

Supplement 1

I gathered information regarding population by administrative unit (*Freguesia*) available from 2011 National Census (Statistics of Portugal); Official cartography of Portugal and Land Use raster from General Directorate of Territory for 2011[1] and 2016 respectively. After verifying that all databases used the same projection system, I started processing the land use information:

1) I joined the shape file with the administrative boundaries with the census data;

2) I recoded the raster in only for classes: Urban (code 111); Semi-Urban (code 112), low density (from code 111 to 411) and no population (code higher than 411).

3) I converted the land use raster to feature using Spatial Analyst, transforming it into points.

4) The Raster with 4 classes was spatially joined to the administrative boundaries and census data file (obtained in point 1). I obtained a dataset with 8,741 points. Each point had all administrative information.

5) I distributed administrative block population density to the 8,741 points taking into account their classification (urban, semi-urban, low density and no population).

- I computed the population density per km2 in each administrative unit.
- I solved, for each administrative block *j*, the equation: $\sum_{i=1}^{i=4} n_i * density_i = density_{tot}$. where n_1 represent the number of points in the administrative block

[1] Year 2011 was preferred over more recent year to avoid compatibility issues with 2011 Census data.

equal to one, n_2 represent the number of grid_code equal to 2 and so on. In simple terms, we introduced a system of equations ensuring that the sum of the parts is equal to the whole. For each administrative block j we have four unknowns ($density_i$), four known variables (n_i) and one equation. This problem has infinite results. Therefore it was necessary to introduce some constraints, assuming a proportion among densities. We assumed that density for urban areas is double when compared to semi-urban areas that, in turn, is double when compared to low density areas. No population areas will have population density set at zero. Now it is possible to solve,[2] for each j, the value for n_2 and solve for n_1 and n_3.

- In each administrative block, points classified in one of the four classes has associated a different population density, while the proportion between point's classification is the same across administrative blocks.

[2] Four unknowns and four equations.

CHAPTER TWO

DOES ACUTE MYOCARDIAL INFARCTION KILL MORE PEOPLE ON WEEKENDS? ANALYSIS OF IN-HOSPITAL MORTALITY RATES FOR WEEKEND ADMISSIONS IN PORTUGAL

ABSTRACT

Introduction: To investigate a possible weekend effect in the in-hospital mortality rate for acute myocardial infarction in Portugal, and whether the delay in invasive intervention contributes to this effect.

Methods: Data from the National 2011–2015 Diagnostic-Related-Group databases were analysed. The focus was on adult patients admitted via the emergency department and with the primary diagnosis of acute myocardial infarction. Patients were grouped according to ST-elevation myocardial infarction and non-ST-elevation myocardial infarction episodes. We employed multivariable logistic regressions to determine the association between weekend admission and in-hospital mortality, controlling for episode complexity (through a severity index and acute comorbidities), demographic characteristics and hospital identifications. The association between the probability of a prompt surgery (within one day) and the day of admission was investigated to explore the possible delay of care delivery for patients admitted during weekends.

Results: Our results indicate that in-hospital mortality rates are not significantly higher for weekend admissions than for weekday admissions in both ST-elevation myocardial infarction (STEMI) and non-STEMI episodes. This result is robust to the inclusion of a number of potential confounding mechanisms. Patients admitted on weekends have lower probabilities of undergoing invasive cardiac surgery within the day after admission, but delay in care delivery during the weekend was not associated to worse outcomes in terms of in-hospital mortality.

Conclusions: There is no evidence for the existence of a weekend effect due to admission for acute myocardial infarction in Portugal, in both STEMI and non-STEMI episodes.

Key words: Acute myocardial infarction, emergency services, in-hospital mortality, Portugal, weekend effect

INTRODUCTION

Acute myocardial infarction (AMI) is a common medical emergency with significant morbidity and mortality rates. AMI accounted for over 12,000 admissions and 4,600 deaths in Portugal in 2014. (1) (2)

The prompt intervention of health professionals is crucial for diagnosis and timely access to reperfusion therapy. Primary percutaneous coronary intervention (PCI) – defined as an emergent percutaneous catheter intervention in the setting of ST-elevation myocardial infarction (STEMI), without previous fibrinolytic treatment – has been shown to be superior to fibrinolytic therapy in STEMI patients. Primary PCI is indicated as the first-line treatment in current guidelines, provided it can be performed expeditiously (i.e. preferably within 90 minutes) and by an experienced team. (3) In order to optimize time between symptom onset and PCI, a coronary fast-track system (*Via Verde Coronária*) has been introduced in Portugal since 2005. This system provides rapid and efficient transport between the pre-hospital setting and a hospital able to perform primary angioplasty or to transfer a patient from one hospital to another with the necessary facilities. (4) Patients with non-ST-elevation myocardial infarction (non-STEMI), particularly those at very high risk, also derive benefit from early access to invasive coronary angiography. (5)

Previously published studies have suggested that patients with AMI admitted to the hospital during weekends have worse outcomes in terms of higher mortality, the so-called 'weekend effect'. (6) (7) Other studies found similar mortality and readmission rates between off-hour and regular hour admissions for AMI. (8) (9) Variation in result outcomes between studies may be due to different designs, namely the populations of

AMI patients studied (STEMI or non-STEMI), country-specific Emergency Department (ED) characteristics or definition of emergency case.

The cause of this weekend effect, when present, however is still unclear. The difference in mortality rates between patients admitted on weekends and weekdays may be associated to asymmetries in demographic characteristics or complexity of episode. (10) Magid *et al.* suggest that worse weekend outcomes in STEMI patients may be explained by delayed access to invasive cardiac surgical procedures. (7) In non-STEMI, other research has found that lower usage rates of an early intervention strategy also contributes to higher in-hospital mortality in patients admitted during the weekend. (11)

To our knowledge, ours is the first study in the literature which compares the weekend and non-weekend effects of in-hospital mortality in admitted patients with AMI in Portugal.

The primary objective of this study is to explore the possible existence of higher mortality rates for AMI patients admitted via ED during weekends or public holidays in Portugal, *ceteris paribus*. Specifically, we are interested in whether being admitted during weekends or public holidays significantly predicts higher mortality after controlling for a range of confounding mechanisms which may also influence mortality rates. In particular, different confounders are introduced in order to account for possible geographical asymmetries in access to healthcare, episode complexity and individual patient characteristics.

METHODS

Data

A retrospective cohort study was conducted using the Portuguese national Diagnostic-Related-Group (DRG) databases between 2011 and 2015. (12) All mainland hospitals integrated within the National Health System (NHS) are represented in the database (episode occurrences in the offshore Portuguese regions of Madeira and the Azores are not available).

The dataset includes administrative and clinical data regarding all inpatients discharged by NHS hospitals, including diagnostics and procedures codes classified using the ninth version of International Classification of Diseases (ICD-9 CM). Each admitted patient is coded with a unique identifier in each year, and as such it is possible to identify all episodes for the same patient within a year but not across years. According to the version 31 of All-Patient Refined Diagnostic Related Groups (APR-31), all episodes are classified in four severity groups: minor, moderate, major and extreme. The severity index is a predictor of mortality and resource use. The classification accounts for the secondary diagnoses, interaction among diagnoses, the patient age and the procedures undergone during the hospitalization. (13)

Study population

The objective of the present study is to investigate the supply of care in an emergency setting related to AMI episodes, focusing on possible variations of in-hospital mortality rates of patients admitted via emergency department during weekends. For this purpose,

the target population includes all patients admitted via ED with a primary diagnosis of AMI. The pooled database across the five years includes 55,025 episodes of ED admissions where the main diagnosis is AMI (ICD-9 CM code 410), corresponding to an average of 11,005 episodes per year. The proportion of episodes occurring during weekdays was 71%, with the remaining 29% occurring during weekends or public holidays. The episodes are separated in two groups: STEMI episodes and non-STEMI episodes, given our expectation that each episode type has systematic differences in populations and treatment approaches. STEMI patients are commonly treated with urgent revascularization, however this early invasive approach is less standard for non-STEMI patients.

Our sample of patients hospitalized for AMI include only individuals over the age of 18. Further, patients discharged against medical advice or transferred to other inpatient institutions had incomplete information, since they interrupted treatment before completion, and therefore their outcome was not observed. These patients may have different preferences related to their healthcare and choose other institutions different from public hospitals. In order to avoid potential biases, these patients are excluded from the analysis, and represent 8,348 observations.

It should be noted that it is not possible to identify patients transferred within the same consortium of hospitals (*Centro Hospitalar*) because this information is not registered in the database. For the same reason, it is not possible to identify whether the episode occurred in a hospital with direct access to primary angioplasty (*via-verde*) or not. In general, each consortium of hospitals includes at least one institution with direct access to primary angioplasty.

Hospitals with less than 50 admission observations were also excluded (representing 75 episodes).[3] This exclusion criterion was introduced in order to avoid multicollinearity when controlling for hospital characteristics in the regression.

Patients presenting both a STEMI and non-STEMI episode in the same year were further excluded from the analysis (representing 820 observations). We cannot attribute these patients to either STEMI or non-STEMI groups directly and thus are unable to associate either of these potential mechanisms as an influencer of weekend mortality rates. Database selection by exclusion criteria and year is resumed in Supplementary material (Table S1).

Patient characteristics were further included to control for individual variability. In order to quantify episode complexity, we considered two different indicators: the enhanced Charlson comorbidity index as in Quan *et al.* (2005) (14) and the severity index as present in the DRG database. The Charlson Index assigns a score of 1, 2, 3 or 6 to each condition which are then summed, resulting in the comorbidity index. The most fatal diseases are assigned the highest score. For example, cancer metastasis and AIDS are given a score of 6. The Charlson index takes into account all in-hospital episodes in a given year. Since a patient identifier is unique only within an administrative year, it is not possible to identify the patient comorbidity level before the episode for a common period of time. A patient surviving an AMI episode for instance, is more likely to have higher Charlson score given that AMI and related comorbidities (heart failure, renal disease) may contribute to other admissions in the same year and therefore increase the score. On the other hand, if the AMI is the first and last episode of a given patient in a given year (for instance, if the

[3] Only three hospitals were excluded: the Oncological Hospital of Lisbon and Porto (IPOL and IPOP) and the District Hospital of Figueira da Foz.

patient has a fatal episode in January) this patient is more likely to have a lower Charlson index, since only one episode was recorded, and possibly multiple diagnoses coded.

On the contrary, the severity index accounts only for a single episode complexity and obviates these issues.

Patients undergoing Percutaneous Transluminal Coronary Angioplasty (PCI), Coronary Artery Bypass Grafting (CABG) and Coronary Angiography were identified using procedure codes ICD-9 CM 00.66, 36.1X and 37.22/37.23 respectively. For those patients with medical interventions, the time (in days) between admission and surgical intervention was computed. Surgical intervention was defined as prompt when occurring within the day after the initial admission.

Statistical analysis

We stratify population characteristics by weekdays and weekends in STEMI and non-STEMI groups for preliminary analysis. Differences in means were tested using parametric tests of proportions for the binary variables; one-way ANOVA test, based on F-statistics for categorical variables (three or more levels); and student's t-test for the remaining variables.

In order to control for confounders, a multivariable logistic regression was estimated based on adjustments for other variables. The dependent variable is a dummy variable representing the mortality of a patient, which equals one when the patient is deceases and zero otherwise. The variable of interest is a dummy variable representing weekend admissions which assumes the value one when the admission occurs on Saturday, Sunday or an official public holiday and zero otherwise. The selection of explanatory variables comes from a stepwise regression with backward elimination of non-significant

confounders (considering a 5% significance level). The inclusion of categorical variables (with 3 or more categories) was decided based on the F-statistic from one-way ANOVA tests, while continuous and dichotomous variable inclusion was based on their p-value. Episode complexity is controlled for through the inclusion of a variable representing the episode severity, which was preferred to Charlson index for the reasons presented above. A dichotomous variable recording whether the patient underwent a cardiac procedure was also considered as a predictor of mortality. The interaction of this variable and prompt intervention was tested as a predictor of mortality, creating a multi-level variable with three potentials: a) no cardiac procedure; b) cardiac procedure without prompt intervention; and c) cardiac procedure with prompt intervention.

Other relevant comorbidities were included in the analysis, namely acute renal failure, cardiac dysrhythmias, cerebrovascular disease and shock (see Supplementary Table S2 for ICD-9 codes). The occurrence of one of these comorbidities during the AMI episode increases its complexity and are expected to increase the probability of death.

The regression controls for demographic characteristics such as age and gender with the expectation that older patients and men will present higher odds of dying.

A control for possible regional asymmetries was introduced with a categorical variable representing the hospital's health region (North, Centre, Lisbon and Tagus Valley, Alentejo and Algarve). A hospital fixed effect was also tested (through a nominal categorical variable which assumed values from 1 to 38 depending in which hospital or consortium of hospitals the episode occurred). The regression further includes a variable, *residence match*, which takes the value of one when the patient's residence is in the same district of the hospital and zero otherwise. This controls for episodes in which the patient must travel longer distance in order to reach the hospital (which may be larger or more

specialised). In these episodes higher probability of death may be anticipated (note that patients transferred from one hospital to another were excluded from the analysis).

Finally, we test for any possible seasonality effect on mortality depending on the year, the week of the year or period of peak influenza in the ED. The peak of influenza is captured by a dichotomous variable which takes the value of one in the weeks with peak incidences of influenza-like illness defined as more than 20 cases/100,000 inhabitants, and zero otherwise. (15) (16) (17) (18) (19) Peak influenza periods may impact the functioning of ED by creating an excess in the demand of healthcare in limited periods of the year. ER congestion due to influenza is expected to have greater impacts on AMI non-STEMI episodes than on STEMI episodes. Authors identify two possible explanations: 1) non-STEMI episodes may have lower priority in emergency room compared to STEMI episodes; and 2) patients with a non-STEMI AMI are more likely to go to hospitals and use private transportation (consequently passing through the emergency room *triage*) instead of calling for emergency services or transportation.

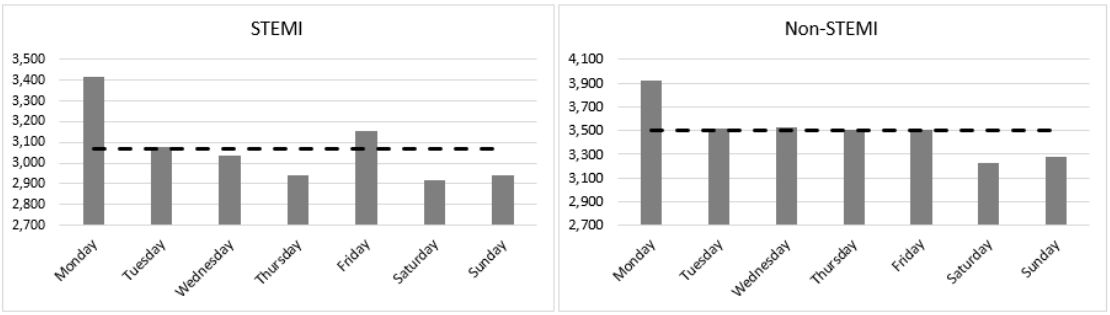
We supplement our analysis with additional regressions to explore further the possible explanation of excess mortality during weekends. In this model, the association between the probability of prompt intervention (within one day) and the day of admission was investigated only for patients undergoing invasive cardiac care procedures. A lower probability of prompt intervention is expected when patients are admitted on weekends. The same set of variables considered in the main regression were also tested with insignificant covariates progressively excluded one at a time (considering a 5% significance level).

Table S3 in the Supplementary Material summarises the variable considered in the analysis.

RESULTS

The analysis included 45,962 episodes (corresponding to 44,820 patients), with 13,292 admissions occurring during weekends or public holidays. A total of 38 hospital centres were included in the analysis. In Figure 1 we see a peak of episodes occurring on Mondays in both STEMI and non-STEMI populations.

Figure 1: Number of AMI episodes by day of week in STEMI and non-STEMI population



STEMI: ST-elevation myocardial infarction.
Dashed line indicates expected mean number of episodes per day.

During 2011 to 2015, invasive cardiac procedures occurred in 64.4% of all episodes (N=29,589). The number of invasive cardiac procedure was 48,793, and often multiple procedures were coded in the same episode. The average patient age (± SD) is 69 ±14 years, with men experiencing more episodes then women (64.1% of the cases).

Yearly mortality rates in STEMI and non-STEMI populations are represented in Figure 2 categorized by weekend and non-weekend admissions. Graphical analysis does not reveal any persistent trends over time for any of the groups. In 2014, a peak of in-hospital

mortality rate is observed in both STEMI and non-STEMI population during weekends, however the difference compared to the remaining years is not statistically significant. Between 2011 and 2013, mortality rates in weekend-admitted non-STEMI patients were lower than the mortality rate of patients admitted during weekdays.

Figure 2: In-Hospital Mortality rate by population and year, weekdays versus weekends.

STEMI: ST-elevation myocardial infarction.

Population characteristics stratified by weekdays *versus* weekends and STEMI and non-STEMI are presented in Table 1.

STEMI and non-STEMI groups differ significantly in terms of their population characteristics as summarized in Table 1 with the exception of their geographic distribution across health regions. The STEMI population is younger, characterized by a higher risk profile in terms of severity index and by a more intensive use of resources (more cardiac interventions and more prompt interventions). Surprisingly, in non-STEMI the number of comorbidities registered, the average length of stay and Charlson index is

significantly higher population than in STEMI population. Within each population, there are no statistically significant differences in patient characteristics admitted on weekends and weekdays (at the 5% significance level). One notable exception however are the proportion of patients undergoing invasive cardiac surgery within the day after the admission. Ages of STEMI patients are on average significantly higher for weekday admissions but the difference was not considered clinically relevant.

It should be noted however that in the five years considered, the in-hospital mortality rate observed during weekends in each sub-population was not statistically different from the mortality rate observed during weekdays.

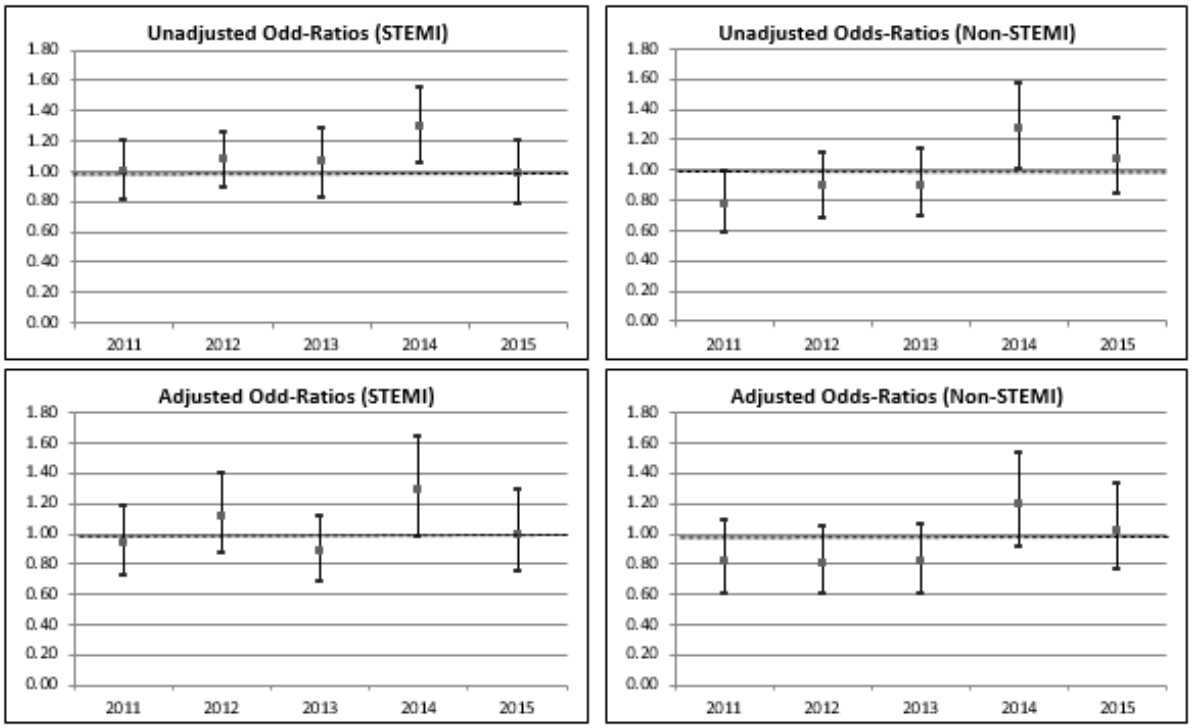
Table 1: Summary of population characteristics

	STEMI			Non-STEMI		
	Weekdays	Weekends	Difference	Weekdays	Weekends	Difference
Observations, number	15,252	6,233		17,543	6,934	
Age, mean (SD)	67.04 (14.22)	66.54 (14.58)	0.49*	71.23 (13.24)	71.10 (13.41)	0.12
Female gender, %	31.64%	31.54%	0.10%	39.48%	39.79%	-0.31%
In-hospital mortality rate, %	12.96%	13.85%	-0.89%	7.64%	7.50%	-0.14%
Severity index, %						
Minor	33.68%	33.32%	0.36%	41.97%	42.49%	0.52%
Moderate	43.82%	43.05%	0.77%	29.43%	28.31%	1.12%
Major	17.16%	17.65%	-0.49%	25.08%	25.12%	-0.04%
Extreme	5.34%	5.98%	-0.64%	3.52%	4.08%	-0.56%
Charlson Index, mean (SD)	1.93 (1.34)	1.92 (1.33)	0.01	2.43 (1.68)	2.39 (1.66)	0.04
Number of diagnosis, mean (SD)	6.80 (3.96)	6.78 (3.98)	0.02	8.06 (4.64)	8.01 (4.56)	0.05
LOS, mean (SD)	7.50 (8.62)	7.32 (8.69)	0.17	8.06 (9.08)	7.95 (7.95)	0.11
Patients undergoing invasive cardiac procedures (%)	72.44%	72.27%	0.17%	57.61%	56.68%	0.93%
Angiography only	27.27%	26.72%	0.55%	32.47%	32.27%	0.20%
PCI	61.44%	61.59%	-0.15%	35.32%	34.45%	0.87%
CABG	0.79%	0.66%	0.13%	2.05%	1.72%	0.33%
Invasive cardiac intervention within the day of admission, %[a]	74.49%	71.23%	3.26%***	44.50%	35.32%	9.18%***
Days between emergency admission and invasive procedure, mean (SD)	0.87 (3.50)	0.94 (3.57)	-0.07	2.12 (4.22)	2.37 (4.21)	-0.25*
Health Region, %						
North	31.05%	31.52%	-0.54%	27.98%	29.45%	-1.47%
Centre	13.27%	12.93%	0.34%	14.45%	13.18%	1.27%
Lisbon and Tagus Valley	43.49%	42.62%	0.87%	43.50%	43.34%	0.16%
Alentejo and Algarve	12.19%	12.93%	-0.74%	14.07%	14.03%	0.04%

[a] Distribution for patients undergoing invasive cardiac intervention only *** p<0.00; ** p<0.01; * p<0.05.CABG: coronary artery bypass grafting. LOS: length of stay. PCI: percutaneous transluminal coronary angioplasty. SD; standard deviation. STEMI: ST-elevation myocardial infarction

In the STEMI and non-STEMI population the unadjusted in-hospital mortality odds-ratios (OR) for weekend admissions is 1.08 (95% C.I. 0.99-1.18) and 0.98 (95% C.I. 0.88-1.09) respectively. The yearly unadjusted and adjusted OR are presented in Figure 3. The confounders considered for the adjustment are listed in Table 2.

Figure 3: Annual unadjusted and adjusted odds-ratios (95% confidence Interval) by population.



STEMI: ST-elevation myocardial infarction.

Among the unadjusted OR, 2014 emerges as significantly different from one in both STEMI and non-STEMI population. After adjusting for confounders, the OR of 2014 maintains a significant difference from one in STEMI population (OR: 1.29, 95% C.I. 1.00-1.66).

The analysis using 2011-2015 pooled data is summarized in the first two columns of Table 2. After controlling for patient and episode characteristics, in-hospital mortality is not significantly different for patients admitted via the emergency department during weekdays and weekends. This is consistent in both the STEMI (OR 1.02, 95% C.I.: 0.92-1.14) and non-STEMI populations (OR 0.93, 95% C.I.: 0.82-1.05).

In regressions 1.1 and 1.2, the OR of cardiac intervention is significantly lower than one, with patients undergoing invasive cardiac procedures with or without prompt intervention being less likely to decease. As mentioned before, the interaction of a cardiac procedure with prompt intervention was tested as a predictor of mortality with the creation of a variable with three levels: a) no cardiac procedure, b) cardiac procedure without prompt intervention and c) cardiac procedure with prompt intervention. We find no significant difference between cardiac procedures with and without prompt interventions and therefore opt to include a measure of cardiac procedure as a binary variable only.

From regression 2.1 and 2.2 results indicate that patients admitted during weekends were less likely to undergo prompt invasive cardiac procedures (with OR 0.78 95% C.I.: 0.72-0.85 and OR 0.64, 95% C.I.: 0.59-0.70 respectively). Delays in the access to such a procedure had no significant impact on in-hospital mortality since cardiac procedure interaction with prompt intervention is not a significant predictor as observed in the regression 1.1 and 1.2.

Table 2: Regressions Results, coefficients are odds-ratios (95% Confidence Interval)

	Pr. of Death STEMI (1.1)	Pr. of Death Non-STEMI (1.2)	Pr. of Prompt Interv STEMI (2.1)	Pr. of Prompt Interv Non-STEMI (2.2)
Age	1.03*** (1.03-1.04)	1.02*** (1.02-1.03)	0.99*** (0.99-0.99)	0.99*** (0.99-0.99)
Female	0.93 (0.84-1.04)	0.84** (0.75,0.93)	0.82*** (0.75-0.90)	0.71*** (0.66-0.77)
Weekend	1.02 (0.92-1.14)	0.93 (0.82-1.05)	0.78*** (0.72-0.85)	0.64*** (0.59-0.70)
Cardiac Procedure	0.20*** (0.18-0.23)	0.31*** (0.27-0.36)		
Influenza	1.01 (0.912-1.13)	1.21** (1.07-1.36)		
Residence match	0.72*** (0.61-0.85)	0.82* (0.69-0.97)		
Cerebrovascular	1.16 (0.99-1.37)	1.30*** (1.12-1.51)	0.64*** (0.52-0.78)	0.62*** (0.52-0.74)
Cardiac Dysrhythmias	1.55*** (1.39-1.72)	1.07 (0.98-1.61)		
Acute renal failure	1.28* (0.01-1.62)	1.26 (0.98-1.61)		
Shock	10.38*** (8.71-12.36)	13.75*** (10.84-17.45)	1.89*** (1.49-2.38)	2.57*** (1.78-3.70)
Severity				
Minor	Reference Group	Reference Group	Reference Group	Reference Group
Moderate	2.06*** (1.71-2.49)	2.96*** (2.29-3.82)		
Severe	4.50*** (3.68-5.51)	7.04*** (5.42-9.14)	0.42*** (0.0.6-0.48)	0.35*** (0.31-0.41)
Extreme	11.63*** (9.12-14.85)	21.27*** (15.86-28.53)	0.63*** (0.50-0.80)	0.43*** (0.0.30-0.40)
ARS				
Region 1	Reference Group	Reference Group		
Region 2	2.42*** (2.06-2.84)	1.57*** (1.30-1.88)		
Region 3	1.60*** (1.42-1.81)	1.37*** (1.19-1.58)		
Region 4	1.33*** (1.12-1.58)	1.27* (1.04-1.54)		
Year				
2012			1.40*** (1.25-1.57)	1.17*** (1.04-1.32)
2013			2.29*** (2.03-2.59)	1.38*** (1.22-1.55)
2014			2.03*** (1.79-2.30)	1.31*** (1.22-1.55)
2015	0.83** (0.73-0.95)		2.39*** (2.10-2.72)	1.38*** (1.22-1.55)
Constant	0.01*** (0.01-0.01)	0.00*** (0.00-0.01)	7.15*** (5.35-9.57)	2.50*** (1.88-3.32)
Pseudo R-squared[1]	36.9%	28.6%	14.3%	14.3%
Nº Observations	21,485	24,477	15,533[2]	13,998[3]

STEMI: ST-elevation myocardial infarction.

A hospital fixed effect was included in regressions 2.1 and 2.2. * For p<.05, ** for p<.01, and *** for p<.001. [1]Mc Fadden's pseudo R-squared; [2]20 observations were dropped because two hospitals were predicting failure or success perfectly. [3]38 observations were dropped because two hospitals were predicting failure or success perfectly.

DISCUSSION

Main findings

This study presents an analysis of the mortality rate for AMI for 45,962 episodes (corresponding to 44,820 patients) focusing on weekday versus weekends or public holiday ED admissions in Portugal between 2011 and 2015. The study also explored the existence of delays in the access to invasive cardiac procedures for patients admitted during weekends, which could contribute to higher in-hospital mortality.

In the five years considered, the in-hospital mortality rate observed during the weekend in each sub-population was not statistically different from the mortality rate observed during weekdays. In the STEMI and non-STEMI population, the unadjusted in-hospital mortality OR for weekend versus weekday admissions were 1.08 (95% C.I. 0.99-1.18) and 0.98 (95% C.I. 0.88-1.09), respectively. After controlling for patient and episode characteristics, in-hospital mortality results are robust and not significantly higher for patients admitted via ED during weekdays and weekends both in STEMI (OR 1.02, 95% C.I.: 0.92-1.14) and Non-STEMI group (OR 0.93, 95% C.I.: 0.82-1.05).

Nevertheless, we found that the delay in invasive cardiac procedure is significantly higher during weekends. This has been shown in previous studies conducted in other countries. (6) (20) However, some may argue that the implementation of the coronary fast-track system (*Via Verde Coronária*) in Portugal should have prevented these asymmetries.

In the present analysis, the delay in access to procedure had no significant impact on in-hospital mortality since cardiac procedure interaction with prompt intervention is not significant in regressions 1.1 and 1.2.

Other findings

AMI episodes (both STEMI and non-STEMI) are most frequent on Monday and statistically different from the expected number of episodes (expected number of episodes is 6,566 while on Mondays episodes averaged 7,343). Other authors find similar patterns in similar contexts (21) (22) (23). Several potential triggering factors, such as stress from initiating the weekly working activity, have been proposed (24). Nevertheless, we find that the probability of death was not statistically different for patients admitted on Monday.

We chose to pool the years 2011 to 2015 in order to achieve a larger sample of patients so as to achieve a more robust analysis. However, when considering the unadjusted OR for in-hospital mortality per year, 2014 emerges as significantly different from one in both STEMI and non-STEMI population. After adjusting for confounders, the OR in 2014 remains marginally significantly different from one in STEMI population (OR: 1.29, 95% C.I. 1.00-1.66). We then looked at patient characteristics in 2014 to help explain such a discrepancy. In 2014 there were significantly more diagnoses for shock (7.38% versus 6.85%), cerebrovascular disease (4.39% versus 3.83%) and influenza-like illness compared to the remaining years.

We are aware of another analysis, by Lopes *et al.* (28), which studied in-hospital mortality for all hospital admissions in Portugal in 2006. The authors found an excess of deaths (in comparison to the predicted amount) during weekends. However, as the population studied is different from the one included in the present analysis, it is difficult to make any direct comparisons.

Limitations

Further research should investigate other possible consequences on patient quality of life, such as slower recovery or long-lasting disabilities. In fact, patients admitted during weekends may have worse outcomes in terms of morbidity while the outcome in terms mortality is similar. It would also be interesting to consider a more precise definition of prompt intervention (i.e. in terms of hours), however the data used for this analysis did not support such a study.

It should be noted that this study was conducted using the 2011-2015 Portuguese national DRG databases which include both administrative and clinical data. (25) Given that this database was not built for research purposes, concerns can be raised regarding the quality of the data, namely the timestamp for each intervention. However, there should be no reason why errors, if any, would systematically vary between weekend and weekday admissions. We found similar studies where the data source was the DRG database, (21) (26) (27) unfortunately the authors had no access to better database to answer the research question.

Nevertheless, the use of DRG databases imposed some limitations. Our definition of prompt intervention is broader than acknowledged in current practice guideline because of limitations related to the timestamp for each episode. We were also unable to include adjustments for socioeconomic status (deprivation index), a common practice in risk models, as this information is not available in the databases.

CONCLUSION

The in-hospital mortality of STEMI and non-STEMI AMI episodes via emergency in Portuguese national hospitals is not significantly higher for weekend admissions than for weekday admissions. After adjusting for confounders, in-hospital mortality results remain robust and not significant. Patients admitted on weekends had lower probability of undergoing invasive cardiac surgery within the day after admission. Nevertheless, the delay in performing cardiac procedure for patients admitted during weekends does not lead to significantly lower outcome in terms of mortality.

ACKNOWLEDGEMENTS

This work is the result of the cooperation with Nicoletta Rosati and Raquel Ascenção. The article was successfully submitted in the Journal of Health Services Research and Policy, and since April, 2018. The full article can be found at: 10.1177/1355819617750687.

REFERENCES

1. Direção Geral da Saúde. Doenças cerebro-cardiovasculares em números. Assessed on january 2017 at https://www.dgs.pt.

2. Instituto Nacional de Estatística. Causas de Morte 2014. Assessed on May 2016 at http://www.ine.pt.

3. Task Force on the management of ST-segment elevation acute myocardial infarction of the European Society of Cardiology (ESC), Steg PG, James SK, Atar D, Badano LP, Blömstrom-Lundqvist C, Borger MA, et al. ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation. Eur Heart J. 2012;33(20):2569-619.

4. Marques N, Faria R, Sousa P, et al. [The impact of direct access to primary angioplasty on reducing the mortality associated with anterior ST-segment elevation myocardial infarction. the experience of the Algarve region of Portugal]. Rev Port Cardiol. 2012;31(10):647-54.

5. Roffi M, Patrono C, Collet JP, et al; Management of Acute Coronary Syndromes in Patients Presenting without Persistent ST-Segment Elevation of the European Society of Cardiology. 2015 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: Task Force for the Management of Acute Coronary Syndromes in Patients Presenting without Persistent ST-Segment Elevation. of the European Society of Cardiology (ESC). Eur Heart J. 2016;37(3):267-315.

6. Kostis WJ, Demissie K, Marcella SW, et al. Weekend versus weekday admission and mortality from myocardial infarction. N Engl J Med 2007;356:1099-109.

7. Magid DJ, Wang Y, Herrin J, et al. Relationship between time of day, day of week,timeliness of reperfusion, and in-hospital mortality for patients with acuteST-segment elevation myocardial infarction. JAMA. 2005;294(7):803-12.

8. Sorita A, Lennon RJ, Haydour Q, et al. Off-hour admission and outcomes for patients with acute myocardial infarction undergoing percutaneous coronary interventions. Am Heart J. 2015;169(1):62-8.

9. Jneid H, Fonarow GC, Cannon CP, et al. Impact of time of presentation on the care and outcomes of acute myocardial infarction. Circulation. 2008;117(19):2502-9.

10. Sorita A, Ahmed A, Starr SR, et al. Off-hour presentation and outcomes in patients with acute myocardial infarction: systematic review and meta-analysis. BMJ. 2014;348:f7393.

11. Agrawal S, Garg L, Sharma A, et al. Comparison of Inhospital Mortality and Frequency of Coronary Angiography on Weekend Versus Weekday Admissions. in Patients With Non-ST-Segment Elevation Acute Myocardial Infarction. Am J Cardiol. 2016;118(5):632-4.

12. Central Administration of Health System [Administração Central do Sistema de Saúde, ACSS, I.P]. 2015.

13. Rutledge R, Osler T. The ICD-9-based illness severity score: a new model that outperforms both DRG and APR-DRG as predictors of survival and resource utilization. J Trauma. 1998;45(4):791-9.

14. Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Medical Care 2005 Nov; 43(11):1073-1077.

15. Instituto Nacional de Saúde Doutor Ricardo Jorge. Boletim de Vigilância Epidemiológica da Gripe Relatório da Época 2010/2011. Accessed on May 2016, at http://www.insa.pt.

16. Instituto Nacional de Saúde Doutor Ricardo Jorge. Boletim de Vigilância Epidemiológica da Gripe Relatório da Época 2011/2012. Accessed on May 2016, at http://www.insa.pt.

17. Instituto Nacional de Saúde Doutor Ricardo Jorge. Boletim de Vigilância Epidemiológica da Gripe Relatório da Época 2012/2013. Accessed on may 2016, at http://www.insa.pt/.

18. Instituto Nacional de Saúde Doutor Ricardo Jorge. Boletim de Vigilância Epidemiológica da Gripe Relatório da Época 2013/2014. Accessed on May 2016, at http://www.insa.pt/.

19. Instituto Nacional de Saúde Doutor Ricardo Jorge. Boletim de Vigilância Epidemiológica da Gripe Relatório da Época 2014/2015. Accessed on May 2016, at http://www.insa.pt/.

20. Khoshchehreh M, Groves EM, Tehrani D, et al. Changes in mortality on weekend versus weekday admissions for Acute Coronary Syndrome in the United States over the past decade. Int J Cardiol. 2016;210:164-72.

21. Manfredini R, Manfredini F, Boari B, et al. Seasonal and weekly patterns of hospital admissions for nonfatal and fatal myocardial infarction. Am J Emerg Med. 2009;27(9):1097-103.

22. Gnecchi-Ruscone T, Piccaluga E, Guzzetti S, et al. Morning and Monday: critical periods for the onset of acute myocardial infarction. The GISSI 2 Study experience. Eur Heart J. 1994;15(7):882-7.

23. Collart P, Coppieters Y, Godin I, et al. Day-of-the-week variations in myocardial infarction onset over a 27-year period: the importance of age and other risk factors. Am J Emerg Med. 2014;32(6):558-62.

24. Willich SN, Lowel H, Lewis M, et al. Weekly variation of acute myocardial infarction: increased Monday risk in the working population. Circulation 1994;90:87-93.

25. Li L, Rothwell PM; Oxford Vascular Study. Biases in detection of apparent "weekend effect" on outcome with administrative coding data: population based study of stroke. BMJ. 2016 May 16;353:i2648.

26. Hansen KW, Hvelplund A, Abildstrøm SZ, Prescott E, Madsen M, Madsen JK, Jensen JS, Sørensen R, Galatius S. Prognosis and treatment in patients admitted with acute myocardial infarction on weekends and weekdays from 1997 to 2009. Int J Cardiol. 2013 Sep 30;168(2):1167-73.

27. Isogai T, Yasunaga H, Matsui H, Tanaka H, Ueda T, Horiguchi H, Fushimi K. Effect of weekend admission for acute myocardial infarction on in-hospital mortality: a retrospective cohort study. Int J Cardiol. 2015 Jan 20;179:315-20.

SUPPLEMENTARY MATERIAL

Table S1: Database selection by exclusion criteria and year

Criteria	2011	2012	2013	2014	2015	Total during weekdays	Total during weekends[a]
Initial database (Emergency Department admissions with main diagnosis AMI)	11,097	11,304	11,430	10,584	10,790	39,411	15,794
Episodes with unknown outcome	1,702	1,721	1,733	1,478	1,714	5,982	2,366
Hospital with less than 50 episodes	13	20	12	18	12	62	13
Episodes of patients with a STEMI and Non-STEMI episode in the same year	154	179	188	155	144	572	248
Final database	9,228	9,384	9,497	8,933	8,920	32,795	13,167

[a] Weekends or Public holidays; [b] Discharge different from death or home or transferred.

Table S2: Comorbidity ICD-9 codes

Comorbidity	ICD-9 code
Cerebrovascular Disease	430.X-438.X
Cardiac Dysrhythmias	427.X
Acute renal failure	584.x, 586.X,788.5
Shock	785.5

Table S3: Variable description

Variable	Type of variable	Codification	Description
Weekend	Dichotomous	=1 if the episode occurred during weekend or public holidays, =0 otherwise	Defines whether the episodes occurred during weekends and public holidays
Death	Dichotomous	=1 if exists; =0 otherwise	Defines whether the episodes was fatal or not
Female	Dichotomous	=1 if female; 0 if male	Sex of the patient at the moment of the episode
Age	Discrete	From 1 to 106	Age of the patient at the moment of the episode
Cardiac Procedure	Dichotomous	=1 if angiography, PCI or CABG occurred during the episode; =0 otherwise	Defines whether an invasive cardiac surgery occurred during the episode
Prompt Intervention	Dichotomous	=1 if cardiac procedure occurs within the day after admission ; =0 otherwise	Defines whether the cardiac procedure (angiography, PCI or CABG) occurred during the first or second day of hospitalization.
Severity	Categorical	Minor; moderate; Severe or extreme	Defines the severity index associated to each episode
Charlson Index	Discrete	Scores clinical condition of the patients and sum them	Defines the complexity of the patient according to his/her comorbidity.
Number of diagnosis	Discrete	Count of the number of diagnosis	Defines the number of diagnosis registered in the episode
LOS	Discrete	Count of the number of days of hospitalization	Defines duration of hospitalization, i.e. the length of stay.
Cerebrovascular Disease	Dichotomous	=1 if exists; =0 otherwise	Defines whether a cerebrovascular disease occurred during the episode
Cardiac Dysrhythmias	Dichotomous	=1 if exists; =0 otherwise	Defines whether a cardiac dysrhythmias during the episode
Acute renal failure	Dichotomous	=1 if exists; =0 otherwise	Defines whether an acute renal failure occurred during the episode
Shock	Dichotomous	=1 if exists; =0 otherwise	Defines whether a shock occurred during the episode
Influenza	Dichotomous	=1 if exists; =0 otherwise	Defines whether the episodes occurred during a peak of influenza (more than 20 cases/ 100.000 inhabitants)
Residence match	Dichotomous	=1 if the district of residence of the patient is the same as the district of the hospital	Defines whether the patients has residence in the same district where the hospital is located
ARS	Categorical	Region North; Center; Lisbon and Tagus Valley and Alentejo and Algarve.	Defines the health region where the hospital is located
Year i, i=2011-2015	Dichotomous	=1 if year is i; =0 otherwise	Defines whether the episode occurred in year i

CHAPTER THREE

HEALTHCARE EXPENDITURE AND FINANCIAL PROTECTION IN THE PORTUGUESE NATIONAL HEALTH SYSTEM

ABSTRACT

Background: To characterize out-of-pocket payments (OOPP) for healthcare and to assess financial protection within the Portuguese National Health System.

Methods: The analysis is based on data collected in the Portuguese Household Budget Survey (2015/2016) and National Representative Health Survey (2014). Households reported OOPP for visits, medication, laboratory tests, diagnostic procedures and treatments and unmet healthcare need due to financial constraints. We analysed OOPP, its progressivity and concentration indexes (CI) as well as the distribution of medical unmet need by income group. Finally, financial protection was characterized, as in Wagstaff and Eozenou (2014), by identifying five household situations: 1) households not reporting any OOPP; 2) households *not being* pushed close to the poverty line (PL) after OOPP; 3) households *being* pushed close to the PL after OOPP 4) households being pushed below the PL after OOPP; 5) households being already below the PL before OOPP, and being pushed further below the PL afterwards.

Results: In 2015/2016, the mean OOPP in the previous year was 698€ (SE=9.3). The OOPP were found regressive, with richer households paying proportionally less than poorer households. All CI, but OOP for medication, are significantly positive. OOPP for medication is the most unequally distributed. Poorest households report higher unmet medical need. The mean percentage of households in each situation is 10.4%; 60.2%; 9.5%; 4.3% and 15.6%, respectively. Distribution among cases significantly differ when analysed by income group.

Conclusions: The proportion of households pushed further below, below to or close to the PL after OOPP are a significant share of the 40% poorest households, which also report higher unmet need. This study arises awareness regarding the need to enhance financial protection, also in a country with a National Health System.

Key words: Health Expenditures, Portugal, Socioeconomic Factors, Insurance Coverage, Surveys and Questionnaires, Health Services Accessibility.

INTRODUCTION

Background

Currently, in Portugal, three health systems co-exist: the universal National Health System (NHS), mainly financed through general taxation; special health insurance schemes (subsystems) for particular professions or sectors (i.e. civil servants, bank and insurance companies' employees) mainly financed by employers' and employees' contributions; and private Voluntary Health Insurance (VHI) [1]. Around 17% of the population has subsystem insurance and 26% has VHI [1].

In 2015, public and private financing contributed to 2/3 and 1/3 of health expenditure, respectively, private financing is above the European Union average (25.5%) being the third highest after Greece and Latvia [2]. In Portugal, the majority (80%) of private health expenditure is associated with Out-Of-Pocket Payments (OOPP) [2] which are defined by the WHO as *"direct payments made by individuals to health care providers at the time of service use"* [3]. It follows that in Portugal OOPP finance approximately 27% of the health system.

OOPP are a major concern in middle income and low income countries [4-7] as well in the USA where health expenditure is mainly privately financed [8,9]. It is important to remember that OOPP are not undesirable *per se*: their introduction in the NHS aims to cope with the over-consumption of healthcare due to moral hazard [10,11].

Nevertheless OOPP may lead some households to financial hardship endangering the overall redistributive effort of the State. Additionally, by linking the payments of

healthcare services to their utilization, OOPP have the potential of deterring users to access healthcare services [12].

Financial Protection within the Universal Health Coverage Framework

OOPP present serious concerns when they endanger users' financial protection. According to the WHO "*Financial protection is achieved when direct payments made to obtain health services do not expose people to financial hardship and do not threaten living standards* [13]."

In Portugal, OOPP in the NHS are usually low (see Supplementary Table S1 for more details) and include many exceptions in terms of users' eligibility. Users may be exempt from co-payments because of[4]: financial hardship[5]; unemployment; pregnancy; being a blood donor or a live donor of cells and tissues; being a refugee or asylum seeker; being a fire-fighter, being 18 or younger; having a high disability (60% or higher); or having a listed disease[6]. In 2017, roughly 60% [1] of the population was exempt from co-payments of laboratory tests and other diagnostic and therapeutic procedures as well as medical visits within the NHS.

Among the services excluded from any co-payments are, those that promote accessibility (as non-urgent transportation for users with high disability) or rational utilization of the healthcare services (such as emergency visits and the first specialist visit when referred by the general practitioner) and others that help prevent and reduce negative externalities

[4] Law decree N.113/2011 and Law decree N. 61/2015.
[5] Households with an average monthly income ≤ 1.5 times the Index of Social Support (Ordinance N. 311-D/2011, of 27th December 2011).
[6] Degenerative and demyelinating neurological diseases, Muscular dystrophy, treatment of chronic pain, chemotherapy for oncological diseases, radiotherapy, mental health, blood clotting protein deficiency, HIV/AIDS, and diabetes.

such as the programs for addictions (alcohol and drugs) and sexually transmitted disease screenings (see ACSS 2016 for more details)[14].

Still, financial protection may be lacking for different reasons: 1) the exclusion of some services from universal coverage such as eye care and dental care[7] [15]; 2) the co-payments for several medications (including many for chronic conditions[8]); and 3) long waiting times for accessing healthcare services within the NHS may also lead households to prefer private providers leading to larger OOPP, especially for those who have no private insurance.

This study aims to show, using data from the last Portuguese Nationally Representative Health Survey (NRHS) [17] and Portuguese Household Budget Survey (PHBS) [18], that financial hardship may exist and be relevant also in countries with National Health Systems. The study is divided in four parts: 1) the characterization of OOPP in Portugal; 2) the characterization of unmet needs for healthcare not satisfied due to financial constraints; 3) the concentration of OOPP by income group (concentration indexes); and, 4) the occurrence of OOPP endangering the households' ability to pay (financial protection).

[7] Some exceptions exist [16].
[8] Co-payment for prescribed medication varies between 15% and 90% depending on the therapeutic class of the medication. Prescribed medication may be free of charge because of: user's financial hardship, the low disease prevalence for potential negative externalities or political considerations.

METHODS

Data

There are two surveys which collected information regarding healthcare expenditure in Portugal: the National Representative Health Survey and the Portuguese Household Budget Survey. Each database has different information which will be useful for studying financial protection in the Portuguese context.

National Representative Health Survey

Data were collected in a nationally representative health survey, conducted in Portugal in 2014 [17]. A stratified clustered probability method was used to select a sample of 22,538 households residing in non-collective dwellings in the national territory. The global response rate was 81% (N=18,204). Within each household, one individual answered the questionnaire. Information was collected either during face-to-face interviews or self-completion of a standardized questionnaire. Proxies were not admitted, therefore only capable persons aged 15 or more answered the questionnaire.

The questionnaire included questions on OOPP for healthcare services paid by the household during the preceding two weeks. The OOPP were defined as direct payments for healthcare services including (delayed) fiscal reimbursement. Households were asked to report OOPP by group: a) medical visits (including emergency visits); b) laboratory tests and other diagnostic and therapeutic procedures c) acquisition of medication; d) surgery and other treatment (i.e. dental; physiotherapy); e) other treatments (homeopathy, acupuncture; contact lenses; dermatologic products or nurse treatments).

In the database, households were classified according to their equivalent monthly income in five groups corresponding to equivalent income quintiles (the exact reported value was not made available for researchers). Also questions regarding the unmet healthcare needs for financial constraints were included. It was asked to report whether the household representative, in the last 12 months, had no need, satisfied need or unmet need due to financial constraints in terms of: a) medical visits, laboratory tests or medical treatments b) dental care c) acquisition of prescribed drugs; and d) mental health (psychiatry; psychologist or therapist visit).

Portuguese Household Budget Survey

Data were collected in a nationally representative budget survey, conducted in Portugal between March 2015 and March 2016 [18]. The main objective of the PHBS 2015/2016 is to characterize the expenditures and income distribution of households living in Portugal, as well as to collect information about some basic comfort indicators.

The PHBS used the same sampling method as the NRHS, and planned to include 17,790 respondents. The global response rate was 64% (N=11,398).

The survey included two parts: 1) a questionnaire completed during face-to-face interviews; and 2) a standardized form which was self-completed with information regarding daily expenditure during a period of 14 days. Within each household, the household's representative (aged 18 and above) answered the questionnaire, proxy respondents were admitted.

The questionnaire included questions about OOPP for services paid by the household during the last month or last year.

Household representatives were asked to report the net monetary and non-monetary income for the 2014 fiscal year. OOPP were reported for the last 12 months or last month. The reported information was more detailed compared to the NRHS. Statistics Portugal carried out a time frame normalization process, transforming all healthcare expenditure in annual expenditure. Table 1 summarizes the details regarding OOPP reported in the PHBS and their classification for the main analysis and additional analysis.

Table 1: Variable regarding out-of-pocket payments collected in the Household Budget Survey and authors' classifications.

PHBS database Information			**Authors' classifications**	
Main classification	**Detailed classification**	**Variable name**	**Main classification**	**Additional classification for comparing with NRHS**
Medications, therapeutic devices and hearing aids	Medication of pharmaceutics specialty	desp_06110	Medication	Medication
	Maternity tests and contraception	desp_06121		
	Other medical and pharmaceutical products	desp_06129		
	Lenses and glasses	desp_06131	Medical devices	Not comparable
	Hearing aids	desp_06132		
	Maintenance of medical devices and therapeutic material	desp_06133		
	Other devices and therapeutic equipment	desp_06139		
Inpatient services	Inpatient services	desp_06300	Other	Not comparable
Medical, paramedical and other outpatient healthcare services	Lab tests and other diagnostic and therapeutic procedures	desp_06231	Medical visits and lab tests and other diagnostic and therapeutic procedures	Lab tests and other diagnostic and therapeutic procedures
	General Practitioner services	desp_06211		Medical Visits
	Specialist doctor services	desp_60212		
	Dental Care Services	desp_06220	Dental Care	Not comparable
	Thermal services, corrective-gymnastic therapy, ambulance transportation, rent of therapeutic equipment	desp_06232	Other	Not comparable
	Other paramedic services	desp_06239		

PHBS: Portuguese Household Budget Survey; NRHS: National Representative Health Survey.

In the main analysis, authors opted to distinguish expenditure for medication from expenditure for medical devices since the former usually has higher co-payments than the latter. Similarly, expenditure for dental care services was analysed separately from other specialists' visits given that this expenditure is mostly excluded from the NHS financing.

Data analysis

We wanted to enhance the highest comparability among the two available sources (NRHS and PHBS). Since NRHS admitted respondents younger than 18, we excluded observations regarding the first age-group (15-19 years old) in both databases[9].

In order to account for differences in households' size, the households' OOPP were adjusted using the OECD-modified equivalent scale [17] in both databases. In the PHBS, households' reported income was also equivalized.

Finally, analysis of data was performed taking into account the sampling weights provided by Statistics Portugal [17,18]. Weights were calibrated in order to ensure the sample's external validity by accounting for the probability of selection of each unit and each group's propensity for non-responses.

OOPP reported in both database will be resumed and compared. Nevertheless, the PHBS database will be more useful for characterizing financial protection because it reports household's income as a continuous variable (while it is a discrete variable in the NRHS

[9] Age is coded in 5-year age groups.

database). The NRHS will be queried to understand the distribution of medical unmet needs across income quintiles, information that was not collected in the PHBS.

Concentration Indexes

In order to study the distribution of OOPP among socio-economic classes, we compared the distribution of OOPP with the distribution of income. Data reported in the PHBS are more suitable for this analysis since the household income is available as a continuous variable.

In first place, we plotted the OOPP concentration curve where the cumulative proportion of the population ranked by income (from lowest to highest) was compared against the cumulative proportion of OOPP. This is an extension of the Lorenz curve [19,20], which allows us to estimate a concentration index that varies between 0 and +1, similarly to Gini index. A positive index indicates that OOPP are progressively distributed in absolute terms (with richer households paying more than poorer households). Kakwani *et al*. [21-23] also presented another index (the Kakwani index) summarizing weak progressivity (whether richer households are paying relatively less than their capacity to pay). The Kakwani index is defined as twice the area between a concentration curve and the Lorenz curve and can be computed as the difference between the concentration index and the Gini index. It follows that the index varies between -1 and +1.When Kakwani index is negative, OOPP are less progressive than income and therefore after paying the OOPP the income distribution becomes more unequal. In other words, with negative Kakwani index the health financing with OOPP is regressive, with poorer households paying proportionally more than their ability to pay. Graphically, when the index is negative, the extended Lorenz curve of OOPP will lay above the income Lorenz curve. The Kakwani

index was initially used as a tool to assess the progressivity of taxation [22], and is often used to assess the distributional effect of a social reform, for instance, the quantification of the impact that the introduction of a poverty subsidy may have on income equity. We computed six concentration indexes and six Kakwani indexes: for overall OOPP and each for OOPP group (medication; medical devices; visits and laboratory tests and other diagnostic and therapeutic procedures; dental care and other OOPP).

All indices are calculated using the so-called convenient covariance approach [20;21;23-25] and standard errors are computed as presented by Kakwani *et al.*[21]. Concentration indexes are assumed to be normally distributed.

In order to compare our results with previously published results [26], we also compute the indexes using consumption as a *proxy* of the ability to pay. We believe that ability to pay is better captured by income than by consumption. This is because propensity to save increases with income, i.e. richer households save proportionally more than poorer households [27].

In supplementary material the comparison of OOPP concentration index estimated in PHBS and in NRHS will be compared. Since in the NRHS the variable income is grouped by equivalent quintile, when computing concentration indexes, we are implicitly assuming that there is no inequality within each income group. Kakwani and Podder show that with grouped data, concentration indexes should be interpreted as the lower limit of the index [28].

Analysis of financial protection

A usual way to measure financial protection is by computing catastrophic healthcare expenditure (CHCE). In general terms, CHCE is defined to occur when OOPP overcome a percentage (or threshold) of ability to pay. In practical terms, the CHCE definition changes according to the definition of the threshold, which lacks a normative reference [29], and the definition of the ability to pay. In poor countries ability to pay is often estimated as the difference between overall consumption and the average consumption for food [5]. In rich countries ability to pay is more often estimated as the difference between the income or overall consumption and the at-risk-of-poverty line [30,31], although other definitions have been suggested [32]. This is because food expenditure loses its relevance when countries get richer: the proportion of household income spent in food shrinks while income spent in housing and transportation increases. For instance, in the 2015/2016 PHBS, the share of households mean expenditure for housing and utilities was as high as 32%, two times the average expenditure for food [30].

Since Portugal is classified as a rich country [33], we opted to define households' ability to pay in terms of equivalent income (EI) minus the equivalized relative poverty line (RPL) (60% of median income). As mentioned above, we computed the ability to pay using the PHBS since income information in the NRHS was only made available as a discrete variable (classifying households from 1 to 5 according to their equivalent quintile). The PHBS also presents the equivalent poverty line estimation (6,951€ per year) [34].

Additionally, we recognize, as other authors [29,32], that measuring financial protection only in terms of CHCE incidence is a limited approach: households are grouped into two

categories only (with or without CHCE). Instead policy makers should be interested in understanding whether there are households which are struggling to meet basic needs, i.e. are below the poverty line, and incurring any OOPP and if there is a significant number of households moving closer to, or below the poverty line because of OOPP.

In this study we follow Wagstaff and Eozenou [29] for both the selection of the closeness to poverty line threshold (120% of the poverty line) and the identification of the five situations in which households may be as a result of OOPP (summarized in Table 2). The situations are mutually exclusive and exhaustive.

Table 2: Out-of-Pocket Payments classification in five cases.

Case Nº	Household's Situation	Description	Definition
1	Absence of OOPP	No OOPP occur	OOPP/(EI-RPL)=0
2	Not at risk of impoverishment	OOPP are positive, but do not bring the household close to the poverty line	0<OOPP/(EI-120%*RPL)≤1
3	At risk of impoverishment	OOPP are positive and bring the household close to the poverty line	OOPP/(EI-120%*RPL)>1 or OOPP/(EI-120%*RPL)<0 with 0<OOPP/(EI-RPL) ≤1;
4	Impoverishing	OOPP are positive and bring the household below the poverty line	OOPP/(EI-RPL)>1
5	Immiserizing	OOPP are positive and occur in households already below the poverty line	OOPP/(EI-RPL)<0

Source: Adapted from Wagstaff and Eozenou [29], Table 1.
OOPP: Out-of-Pocket Payments; EI: Equivalent Income; RPL: Relative Poverty Line.

In order to compare our results with previously published results for Portugal [26,35], we also computed four reference values of CHCE, defined to occur, when OOPP are higher than 40%, 30%, 20% and 10% of household ability to pay, respectively. For comparability reasons, ability to pay was here considered as the difference between the household's overall expenditure and the average households' expenditure for food (without alcoholic

drinking) [4,5,36], both normalized using either square root equivalence scale as in Kronenberg and Barros [35] or the equivalent OECD scale as in Quintal and Lopes [26]. In Kronenberg and Barros [35] CHCE was computed using the Portuguese 2000 and 2005 PHBS database, while Quintal and Lopes [26] used the 210 PHBS.

Finally, we tested whether the distribution among cases was significantly different among income quintiles using a Chi-squared test and considering a 5% significance level.

RESULTS

Characterization of Out-Of-Pocket Payments

After excluding the respondents aged 19 or less, in the NRHS we had data of 16,876 households in the NRHS and 11,377 households in the PHBS.

In the NRHS, the average household's equivalent OOPP in the previous two weeks was of €37.91 (SE=1.30), almost two times the median value (20.0€). Households incurring a positive OOPP, reported, an average equivalent expenditure of €60.96 (SE=2.01), which in Portugal, corresponds to 11.4% of the mean household equivalent income in the last two weeks[10] [29]. From another point of view, it was found that 37.5% of households reported no OOPP (for any reason) in the previous two weeks.

In the PHBS the household's equivalent OOPP in the last year averaged 697.92€ (SE=9.29), corresponding to 26.84€ (SE=0.36) expenditure in the last two weeks[11] or a median value of €17.88. The majority of households (90.8%), reported positive OOPP in

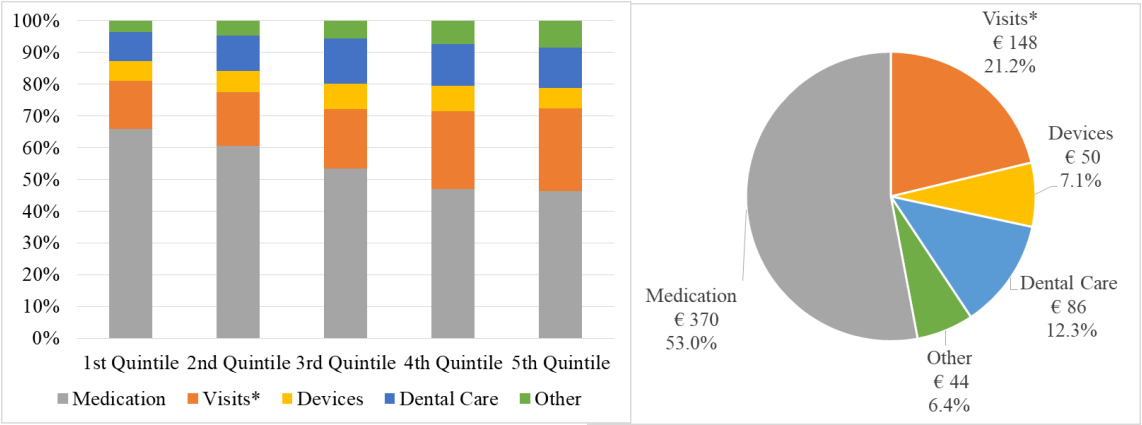
[10] Assuming a uniform distribution of the income during the year.
[11] Assuming a uniform distribution of the OOPP during the year.

the previous 12 months. It fallows that households incurring a positive OOPP, reported, an average equivalent annual expenditure of €768.60 (SE=9.83), which, on average, is 6.1% of household equivalent income.

In both databases, the proportion of positive report significantly varied among different types of OOPP. In the NRHS, the proportion of households with inexistent OOPP for laboratory test and diagnostic procedures is as high as 87.6%, while only 45.0% stated no expenses for medication. This result may be influenced by the short time frame of reference (two weeks). In the PHBS, expenditure for laboratory tests and other diagnostic and therapeutic procedures was reported zero for 83.6% of households, while expense for medication (both prescribed and non-prescribed medication) was null only for 16.1% of households and accounted for the majority of OOPP in the three lowest quintiles.

In Figure 1, we represent the OOPP distribution by source and income quintile.

Figure 1: On the left, Out-of-Pocket Payments by source and income quintile, on the right the overall Out-of-Pocket Payments by source.



*Includes laboratory tests and other diagnostic and therapeutic procedures. Source: Portuguese Household Budget Survey [18].

In Figure 1 it can be noticed that the majority of OOPP is associated to medication and that dental care is responsible for over 10% of overall OOPP. The high contribution of

dental care together despite the fact that only 16.0% of households incur OOPP for dental care, is because the expenses for dental care are very large when occurring (on average €462 annually, SE=11.26).

As expected, the average equivalent OOPP increases with income being 502.74€ (SE=16.67), 570.75€ (SE 16.77), 641.77€ (SE=18.40), 777.90€ (SE=23.03) and 996.70€ (SE=24.97) in each quintile, respectively.

Characterization of unmet medical needs

In the NRHS, 85.6% (SE=0.004) of individuals did perceive medical needs in the previous 12 months, among these, 30.2% (SE=0.01) reported at least one unmet medical need (for medical visits, laboratory tests or treatments, dental care, prescribed drugs or mental care). When healthcare utilization was perceived as needed, poorest households' representatives reported more frequently the lack of utilization due to financial constraints compared to richer households. This is true for all types of healthcare needs. Results are presented in Table 3.

Table 3: Proportion of households reporting unmet need when the need of medical care was perceived.

Income quintile	**Medical visits, lab tests or treatments**		**Dental care**		**Prescribed drugs**		**Mental care**	
	%	SE	%	SE	%	SE	%	SE
First	25.6%	0.02	54.0%	0.03	22.0%	0.02	50.2%	0.05
Second	14.4%	0.01	42.5%	0.03	12.7%	0.01	38.9%	0.05
Third	14.5%	0.02	33.4%	0.02	12.5%	0.02	29.3%	0.05
Fourth	8.8%	0.01	24.8%	0.02	6.1%	0.01	16.6%	0.04
Fifth	4.5%	0.01	10.4%	0.01	3.0%	0.01	12.2%	0.04

SE: Standard Error. Source: National Representative Health Survey [17].

It should be highlighted that over half of respondents in the first income quintile reported having limited access to either dental or mental care because of financial constraints although they perceived them as being needed.

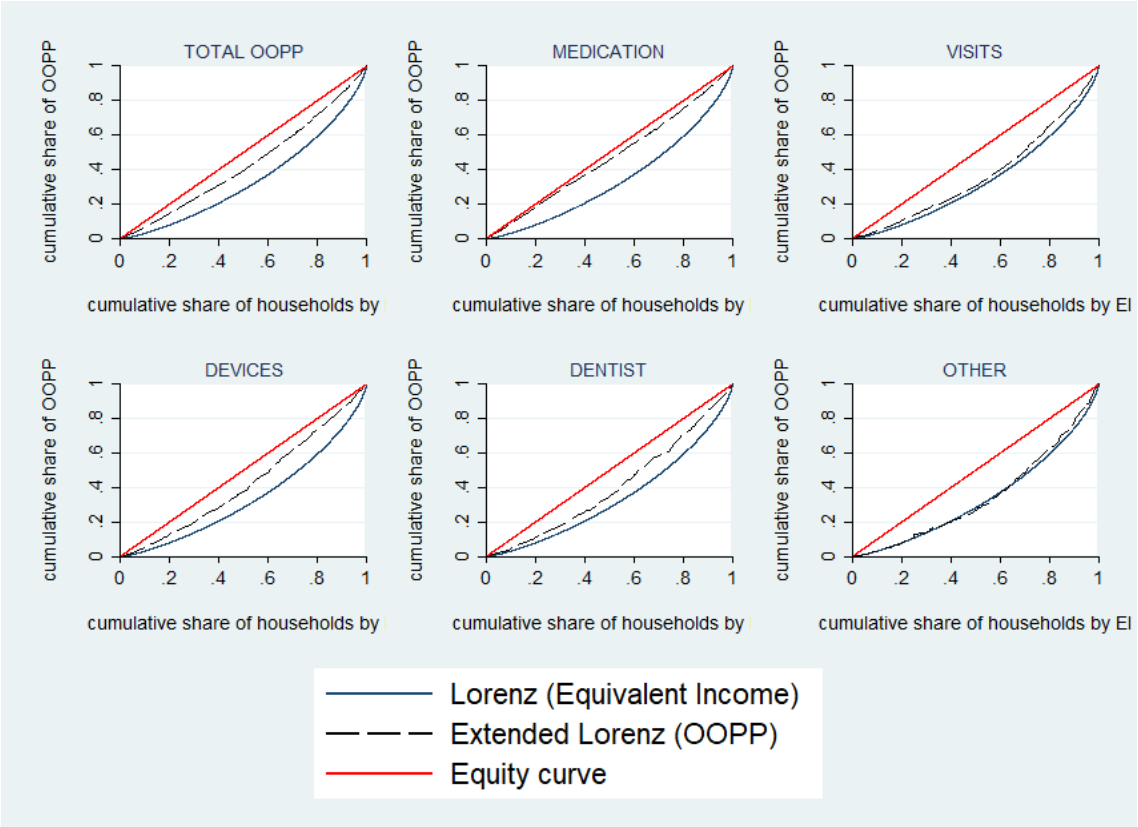
Here, unmet need does not imply the complete lack of utilization of healthcare: there are individuals reporting healthcare utilization and/or OOPP and unmet medical needs. It should be noticed that this definition of unmet medical need, naturally leads to an overestimation of the unmet need because it gives the same relevance to partial unmedical need (under consumption or partial rationing) and complete unmet need (non-utilization).

Concentration Indexes

As mentioned before, in the main analysis, concentration indexes and Kakwani indexes were estimated using the PHBS, since here households can be ranked continuously based on their income.

The comparison of concentration curves, Lorenz curves and equity lines are represented in Figure 2. Here the ability to pay is measured in terms of equivalent income, results where ability to pay is measured in terms of expenditures are presented in the supplementary material (Supplementary Figure F1).

Figure 2: Extended Lorenz curve for overall Out-Of-Pocket Payments (OOPP) and by type (visits and tests, medication, medical devices, dental care, and other). Ability to pay measured in terms of Equivalent Income (EI).



OOPP: out-of-pocket payments; EI: equivalent Income. Source: PHBS [18].

Graphically, we see that the extended Lorenz curves always lay between the Lorenz curve and the equality line, meaning that OOPP are less progressive than income. This means that overall, OOPP increase with income but increase less than proportionally than income. In other words, OOPP are regressive with richer paying less than proportionally to their ability to pay. Additionally, we see that OOPP for medication almost overlaps the 45° line (e.g. the equity line) meaning that expenditure for medication is almost independent of income.

The results in terms of concentration index and Kakwani index are presented in Table 4.

Table 4: Concentration indexes and Kakwani indexes estimations for 2015/2016 and comparison with previously published estimations.

	Concentration Indexes		Kakwani indexes		
	Income	Expenditure	Income	Expenditure 2010[a]	Expenditure 2015
Total	0.147***	0.226***	-0.176***	-0.074***	-0.074***
Medication	0.067***	0.120***	-0.256***	-0.225***	-0.179***
Medical Visits	0.264***	0.367***	-0.059***	-0.005	0.067***
Medical Devices	0.157***	0.238***	-0.166***	0.008	-0.062**
Dentist	0.198***	0.320***	-0.125***	0.063***	0.020
Other	0.310***	0.430***	-0.013	NA	0.131***

[a]Estimated by Quintal and Lopes [26]. NA: Not available. ***p<0.001; **p<0.01.

The concentration index of overall OOPP (CI=0.147, p<0.001) is significantly positive and Kakwani index is significantly negative (KI=-0.174, p<0.001). This means that, overall, OOPP are higher in the richest households (progressive in absolute terms), but regressive in relative terms with richer households paying relatively less than their ability to pay. Medication and acquisition of medical devices are the most regressively

distributed OOPP (they present the lowest Kakwani index values). As expected, we find that Kakwani indexes measured with income are more negative than Kakwani indexes when measured with expenditure, meaning that the financing with OOPP is always more regressive when measuring ability to pay in terms of income rather than in terms of expenditure. These results reflect the higher propensity to save of richer households. By comparing the results for 2015 with the previously published results presented for 2010 [26], we find that the overall regressivity of the financing is unchanged (KI=-0.074, p-value<0.000), while the regressivity of medication (the main contributor) decreased (from KI=-0.225 to KI -0.176).

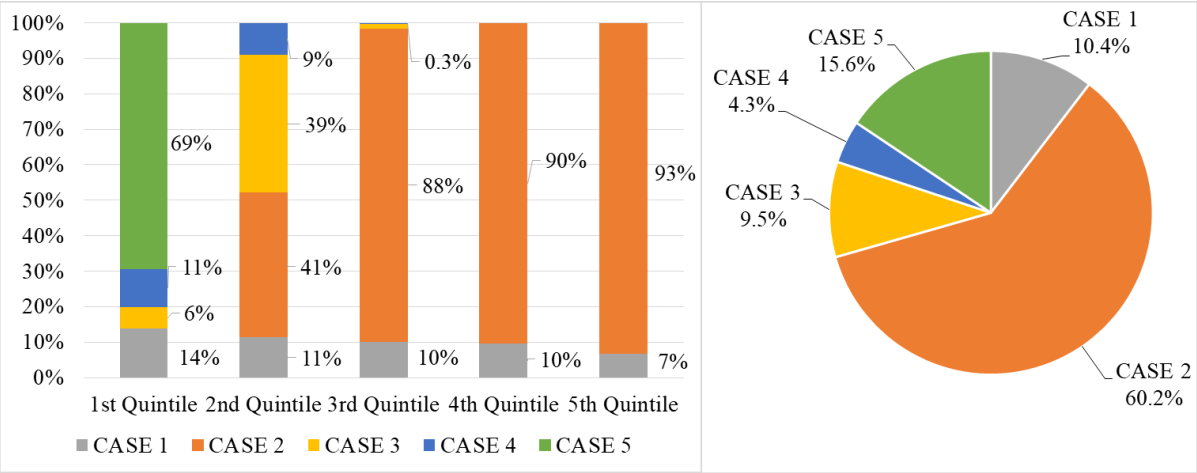
Comparison between concentration indexes computed using the NRHS and the PHBS are presented in supplementary material, table S2.

Financial Protection

Overall we found that the most frequent household situation was with OOPP not leading households to risk of impoverishment (60.2%, SE=0.01, case 2). As presented above, 10.2% of households reported no OOPP in the last year according to data collected in the PHBS. The proportion of households in an immiserizing situation (case 5) was estimated at 15.6% (SE=0.004), while OOPP pushed households closer to or below the poverty line (cases 3 and 4) in 9.5% (SE=0.003) and 4.3% (SE=0.002) of situations, respectively.

The results regarding financial protection by income quintile are presented in Figure 3 and detailed in Supplementary Table S3. The distribution in the five groups is significantly different among income quintiles.

Figure 2: On the left, Classification of households in five financial protection cases, by income quintile, on the right the overall distribution among five financial protection cases.



Case 1: No Out-of-Pocket Payments; Case 2: Not at risk of impoverishment out-of-pocket payments; Case 3: At risk of impoverishment out-of-pocket payments; Case 4: Impoverishment out-of-pocket payments; Case 5: Immiserizing out-of-pocket payments.

The immiserizing case (case 5) is only present in the first equivalent income quintile, where all households living below the poverty line are represented.

We found that 13.8% of the poorest households (SE=0.01) incurred no OOPP and the rest spent on average 563.81€ (SE=14.76) on OOPP in the last 12 months, dragging them mostly to an immiserizing situation (69.5%).

As expected both the proportion of households at risk of impoverishment (case 3) and becoming impoverished as a result of OOPP (case 4) decreases when income increases. These cases are inexistent in the last two income quintiles.

When defining CHCE as the case of household's OOPP exceeding 40% of disposable income (difference between income and average food expenditure), we found that only 1.04% (SE=0.001) of households are at risk of poverty.

This estimate is much lower than the estimate presented by Kronenberg and Barros [31] using the same method and a previous versions of the same database (2000 and 2005) and almost half of the last estimate (2010) [26]. Table 5 below presents the estimate along time.

Table 5: Catastrophic healthcare expenditure estimate considering different disposable income thresholds and catastrophic healthcare expenditure by income quintile (considering 40% threshold).

	2000[a]	**2005[a]**	**2010[b]**	**2015 Comparable with 2000 and 2005**	**2015 Comparable with 2010**
CHCE considering different thresholds of disposable income.					
CHCE 10%	29.0%	32.8%	28.2%	29.0%	29.7%
CHCE 20%	16.7%	15.4%	11.5%	9.1%	9.6%
CHCE 30%	11.0%	8.6%	5.0%	2.9%	3.3%
CHCE 40%	7.9%	5.0%	2.1%	1.0%	1.2%
CHCE 40% by equivalent income quintile					
1st quintile	22.3%	13.5%	4.1%	2.8%	3.2%
2nd quintile	11.1%	7.2%	3.0%	1.2%	1.2%
3rd quintile	3.6%	2.6%	1.1%	0.1%	0.1%
4th quintile	1.6%	1.3%	1.3%	0.2%	0.2%
5th quintile	0.8%	0.6%	1.1%	0.0%	0.0%

CHCE: Catastrophic Healthcare Expenditure. [a] Kronenberg and Barros (2012) [31] ; [b]Quintal and Lopes (2015) [26]

Comparing previously published results with our results, we find that there is a progressive reduction in the proportion of households incurring CHCE between 2000 and 2015 for any definition of CHCE considered. The only exception is when defining CHCE

to occur when OOPP overcome the 10% threshold of the household's disposable income. In this case, CHCE increases between 2000 and 2005, decreases between 2005 and 2010 and increases again after 2010. Surprisingly, in both 2010 and 2015 the proportion of CHCE in the fourth quintile is slightly higher than in the third quintile. It is worth noting that this measure of financial protection does not account for households with negative ability to pay, but ability to pay is rarely negative when defined as the difference between consumption and average food consumption.

Some of the results presented in Table 4 may be driven by the definition of CHCE considered in the analysis. Here the households' ability to pay depends on the difference between consumption and average households' expenditure in food. The average incidence of food on income is decreasing in time: being 19%, 16% and 14% in 2000, 2005 and 2015, respectively. This means that the disposable income, as defined here, is increasing in time and may be an important driver of the difference in the results presented above [33;37;38].

DISCUSSION

Main Findings

In the 2015 PHBS, 90% of Portuguese households reported OOPP in the previous year, with an average equivalent expenditure of €698. Medication was the main contributor for OOPP and expenses due to medication were found to be proportionally distributed among income groups. The average OOPP reported in previous two weeks in the NRHS is 38€, with a proportion of households with positive expenditure of 62%.

When comparing the average expenditure in the PHBS (27€) to the NRHS (39€), we found that the former is significantly lower than the latter. This discrepancy may be explained by the recall bias and difference in the questions posed. In fact, most of the questions regarding health expenditure in the PHBS referred to the last year. If this is the case, we should consider the presented result as a significant sub-estimate of the true results. Additionally, we found that median values (18€ *versus* 20€) are more consistent than averages (27€ *versus* 39€). This is because in the NRHS we found more extreme values than in the PHBS. The proportion of households reporting any OOPP is instead higher in the PHBS, this may be explained by seasonality and frequency of healthcare consumption (healthcare consumption is generally greater during winter, and chronic diseases often require monthly acquisition of medication).

Overall, we found that richer households contribute proportionally less than poorer households in terms of healthcare OOPP. In other words, the OOPP were found to be regressive in Portugal. Even if OOPP in poorer households is lower than in richer households, it is still too large compared to their ability to pay. This result is in line with previous results for Portugal [26;39;40].The analysis of progressivity of payments

suggests that regressivity has decreased compared with 2000 [40] and was unchanged compared to 2010 [26]. Additionally, our findings suggest that the access for poorer households is, at least partially, limited due to financial constraints. This suggests that OOPP are deterring some users from accessing (partially or totally) healthcare services implying the existence of a financial barrier. In fact the representatives of poorer households report more frequently unmet need for healthcare due to financial constraints compared to richer households.

In terms of financial protection we found that more than two thirds of the poorest households incurred OOPP, pushing poor households deeper into poverty (immiserizing). Furthermore, overall, more than 14% of households fell below or close to the poverty line after paying OOPP. These results bring attention to the urgent need for more redistribution of OOPP to enhance financial protection of the poor, especially for the poorest 40% of households.

It should be considered that co-payment within the NHS decreased since May 2016 (Supplementary Table S1), and this change was not represented in this analysis, since data were collected before this date.

Limitations

This study presents many limitations.

As always, national surveys fail to capture the entire population, excluding for instance, students living temporarily in another residence, homeless, hospitalized or nursing home populations [41]. Additionally, the PHBS had a relatively low response rate (64%), raising concerns regarding the representativeness of the sample.

A major limitation exists in the definition of OOPP (in both surveys). The questions regarding OOPP were not ideal: households reported all payments including fiscal reimbursement, although fiscal reimbursement should not be considered in OOPP. At the time of the data collection, households were entitled to the reimbursement of 15% of overall health expenditure (excluding-over-the-counter medicines) up to a yearly limit of €1,000. Also, in the PHBS, income and OOPP were not reported for the same time frame: income was reported for the 2014 fiscal year, while OOPP were either reported for the 12 months or two weeks prior to the interview (2015/2016).

Additionally, researchers had to make some discretionary decisions to classify households in five situations based on their OOPP. Namely, the threshold of the basic needs was set at 60% of median income and the proximity to poverty line was defined to occur when OOPP cause households to fall to 120% or less of the poverty line. But according to the preliminary results from Thomson *et al.* [32], using the poverty line (60% of median income) for approximating the basic needs line is conservative compared to the method they proposed (based on mean consumption of a basket of goods). The 120% reference for defining households at risk of poverty was in line with the literature [28] and seems reasonable.

When Wagstaff *et al.* [42] analysed CHCE trends in Portugal, they found that CHCE increased between 1990 and 2010 if considering as catastrophic the expenditures exceeding 10% of household's ability to pay (measured in terms of total consumption) and was unchanged if considering a 25% threshold. These results are not comparable with our results. When comparing our finding with Kronenber and Barros [35] and Quintal and Lopes [26], we found a negative trend between 2000 and 2015 considering all definitions of CHCE except the 10% threshold definition. Nevertheless we believe that it

is restrictive to summarise financial protection in terms of CHCE only. We also consider that the ability to pay in a rich country such as Portugal should not be measured in terms of difference between total consumption and mean food expenditure, because households' main expenditure is usually for housing and utilities.

Finally, OOPP do not include transportation costs and indirect costs associated with the waiting time. We had no information about these variables, but these costs can only increase the cost of accessing healthcare and should be an object of further research assessing financial protection.

CONCLUSION

We found that in 2015 the majority of Portuguese households reported OOPP in the last year. Medication was the largest contributor for OOPP. OOPP were found to be regressive, with poorer families spending on average proportionally more than richer families. The proportion of households who became impoverished as a result of OOPP, or who paid OOPP while already being impoverished was found to be relevant. Additionally, many claim that they are reducing access to healthcare due to financial constraints. The presented study has many limitations, however it raises awareness regarding the need of enhancing financial protection even in a country with a National Health System.

REFERENCES

1. Simões, J., Augusto, G.F., Fronteira, I., Hernández-Quevedo, C. Portugal: Health system review. Health Systems in Transition. 19(2):1–184. (2017).

2. OCDE. Health Spending. https://data.oecd.org/healthres/health-spending.htm (2017). Accessed 22 January 2018.

3. World Health Organization (WHO). Out-of-pocket payments, user fees and catastrophic expenditure. http://www.who.int/health_financing/topics/financial-protection/out-of-pocket-payments/en/ (2017). Accessed 22 Jan 2018.

4. Yardim, M.S., Cilingiroglu, N., Yardim, N. Catastrophic health expenditure and impoverishment in Turkey. Health Policy. 94:26–33. (2010).

5. Wagstaff, A., van Doorslaer, E. Catastrophe and impoverishment in paying for health care: with applications to Vietnam 1993–1998. Health Economics. 12:921–934. (2003).

6. Amaya-Lara, J.L. Catastrophic expenditure due to out-of-pocket health payments and its determinants in Colombian households. Int J Equity Health. 15(1):182. (2016).

7. Brinda, E.M., Kowal, P., Attermann, J., Enemark, U.: Health service use, out-of-pocket payments and catastrophic health expenditure among older people in India: the WHO Study on global AGEing and adult health (SAGE). J Epidemiol Community Health. 69(5):489-94. (2015).

8. Waters, H.R., Anderson, G.F., Mays, J.: Measuring financial protection in health in the United States. Health Policy.;69:339–349. (2004).

9. Himmelstein, D.U., Warren, E., Thorne, D., Woolhandler, S.: Illness and injury as contributors to bankruptcy. Health Affairs (Millwood). (2005).

10. Zeckhauser, R.J.: Medical insurance: A case study of the tradeoff between risk spreading and appropriate incentives. J. Econ. Theory 2(1), 10–26 (1970).

11. Drummond, M., Towse, A.: Is it time to reconsider the role of patient co-payments for pharmaceuticals in Europe? Eur J Health Econ. 13(1):1-5 (2012).

12. Manning, W.G., Newhouse, J.P., Duan, N., et al.: Health Insurance and the Demand for Medical Care. The RAND Corporation, Santa Monica, CA (1988).

13. World Health Organization (WHO). Health Financing-Financial Protection. (2018). http://www.who.int/health_financing/topics/financial-protection/en/ Accessed 22 Jan 2018.

14. ACSS 2016. Revisão de categorias de isenção e atualização de valores das taxas moderadoras. http://www.acss.min-saude.pt/wp-content/uploads/2016/09/FAQ_taxas-moderadoras_Abril-2016-05-05.pdf. Accessed Aug 27, 2018.

15. Paris, V., Hewlett, E., Auraaen, A., Alexa, J., Simon L.: Health care coverage in OECD countries in 2012. *OECD Health Working Papers*. No. 88, OECD Publishing, Paris. (2016).

16. National Health System Website 2018 https://www.sns.gov.pt/sns-saude-mais/saude-oral/. Accessed Aug 27, 2018.

17. Statistics Portugal and Instituto Nacional de Saúde Doutor Ricardo Jorge. Inquérito Nacional de Saúde 2014 [National Representative Health Survey]. Microdata. (2018)

18. Statistics Portugal. Household Budget Survey/HBS 2015/2016. Microdata. (2018).

19. Wagstaff, A., van Doorslaer, E.; Paci, P.: Equity in the finance and delivery of health care: some tentative cross-country comparisons. Oxford Review of Economic Policy 5(1):89-12. (1989).

20. Wagstaff A., van Doorslaer E.; Paci P.: On the measurement of horizontal inequity in the delivery of health care. Journal of Health Economics. 10(2):169-205. (1991)

21. Kakwani, N., Wagstaff, A., van Doorslaer, E. Socioeconomic inequalities in health: measurement, computation, and statistical inference. Journal of Econometrics, 77:87-103. (1997).

22. Kakwani, N.. "Measurement of Tax Progressivity: An International Comparison." Economic Journal 87(345): 71–80. (1977).

23. O'Donnell, O., E. van Doorslaer, A. Wagstaff and M. Lindelow Analyzing Health Equity Using Household Survey Data: A Guide to Techniques and Their Implementation, Washington, DC: The World Bank. (2008).

24. Kakwani, N. Income Inequality and Poverty: Methods of Estimation and Policy Applications. New York: Oxford University Press. (1980).

25. Jenkins, S.P. Calculating income distribution indices from micro-data. National Tax Journal 41: 139-142. (1988).

26. Quintal C, Lopes J. Equity in health care financing in Portugal: findings from the Household Budget Survey 2010/2011. Health Econ Policy Law. Jul;11(3):233-52. (2016).

27. Blanchard, O.. Macroeconomics. (Fourth ed., p. 59). Toronto: Pearson Education Inc. (2006).

28. Kakwani, N., Podder, N.: Efficient Estimation of the Lorenz Curve and Associated Inequality Measures from Grouped Observations. Econometrica, 44,137-48 (1976).

29. Wagstaff A., Eozenou P.: CATA meets IMPOV. A unified approach to measuring financial protection in health. Policy Research Working Paper 6861. Washington (DC): The World Bank. (2014).

30. Bredenkamp C, Mendola M, Gragnolati M. Catastrophic and impoverishing effects of health expenditure: new evidence from the Western Balkans. Health Policy Plan. Jul;26(4):349-56. (2011).

31. Dorjdagva J, Batbaatar E, Svensson M, Dorjsuren B, Kauhanen J. Catastrophic health expenditure and impoverishment in Mongolia. Int J Equity Health. 11;15(1):105. (2016).

32. Thomson S, Evetovits T, Cylus J, Jakab M. Monitoring financial protection to assess progress towards universal health coverage in Europe. (2016). http://www.euro.who.int/__data/assets/ pdf_file/0005/317543/10-Research-article-monitoring-financial-protection-assess-progress-universal-health-coverage-Europe. pdf?ua=1 Accessed Oct 23, 2017.

33. World Bank 2018. Country and Lending Groups. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups. Accessed on July 1, 2018.

34. Statistics Portugal. Household Budget Survey/HBS 2015/2016. (2017). www. ine.pt. Accessed Oct 23, 2017.

35. Kronenberg C, Barros PP. Catastrophic healthcare expenditure - drivers and protection: the Portuguese case. Health Policy. Mar;115(1):44-51. (2014)

36. World Health Organization. (2005). Distribution of health payments and catastrophic expenditures Methodology / by Ke Xu. Geneva: World Health Organization. http://www.who.int/iris/handle/10665/69030

37. Statistics Portugal. Household Budget Survey/HBS 2005/2006. (2008). www.ine.pt. Accessed Oct 23, 2017.

38. Statistics Portugal. Household Budget Survey/HBS 2000. (2002). www.ine.pt. Accessed Oct 23, 2017.

39. Pereira, J.A. Estimates of health care finance progressivity in Portugal: how robust? Estudos de Economia, 8(3):351-372. (1998).

40. Simões, J., P. Barros and J. Pereira (coordinators), Final Report of the Commission for the Financing Sustainability of the National Health Service, Lisbon: Ministry of Health [Relatório final Comissão para a Sustentabilidade do Financiamento do Serviço Nacional de Saúde.] Fevreiro 2007. http://www.sg.min-saude.pt/sg/conteudos/noticias/sustentabilidade+sns.htm. Accessed Sept 23, 2018.

41. Anthony, B. Atkinson. Inequality What Can Be Done? First Edition, Harvard University Press (2015).

42. Wagstaff A, Flores G, Hsu J, Smitz MF, Chepynoga K, Buisman LR, van Wilgenburg K, Eozenou P. Progress on catastrophic health spending in 133 countries: a retrospective observational study. Lancet Glob Health. Feb;6(2):e169-e179. (2018).

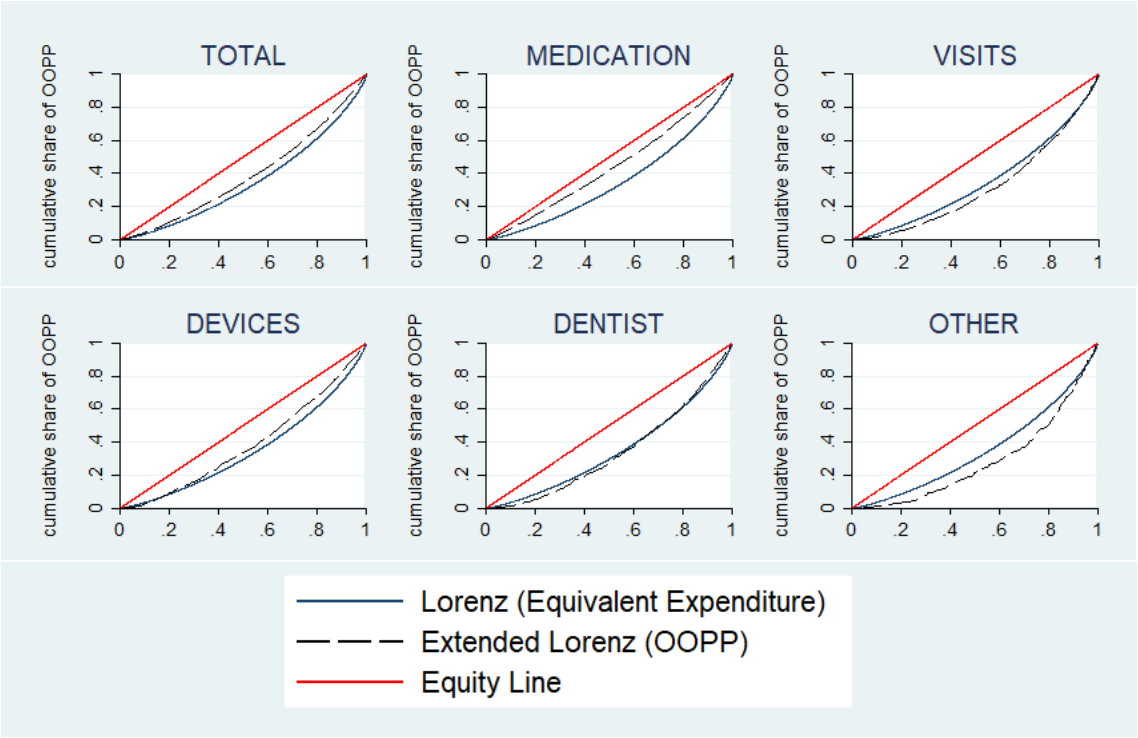
SUPPLEMENTARY MATERIAL

Supplementary Table S1: Co-payment fees in Portugal

Service	**Co-payment before 01/05/2016**	**Co-payment since 01/05/2016**
Non-specialist medical doctor visit	5.00 €	4.50 €
Specialist medical doctor visit	7.75 €	7.00 €
Home visit*	10.30 €	9.00 €
Visit without the presence of the patient (i.e. prescriptions)*	3.10 €	2.50 €
Nurse or other health professional visits in Primary Care	4.00 €	3.50 €
Nurse or other health professional visits in Hospital	5.15 €	4.50 €
Day hospital	Lab tests and exams max. 25.00 €	None
Emergency Room basic specialization level (*Urgência Básica*)	15.45 €	14.00 €
Emergency Room medium specialization level (*Urgência Médico-Cirúrgica*)	18.00 €	16.00 €
Emergency Room high Specialization level (*Urgência Polivalente*)	20.60 €	18.00 €

*These co-payments are reduced when visits occur in the primary care context. Source: Adapted from ACSS 2016, (p.18) [14]

Supplementary Figure F1: Extended Lorenz curve for overall Out-Of-Pocket Payments (OOPP) and by type (visits and tests, medication, medical devices, dental care, and other). Ability to pay measured in terms of Equivalent Expenditure (EI).



Supplementary Table S2: Comparison of concentration indexes

Main classification	Detailed classification in PHBS	Classification in NRHS	Concentration Index in NRHS	Concentration Index in PHBS
Medications, therapeutic devices and hearing aids	Medication of pharmaceutics specialty	Medication	0.02 (SE=0.01)	0.07 (SE=0.01)
	Maternity tests and contraception			
	Other medical and pharmaceutical products			
Medical, paramedical and other outpatient healthcare services	Lab tests and other diagnostic and therapeutic procedures	Lab tests and other diagnostic and therapeutic procedures	0.31 (SE=0.02)	0.30 (SE=0.02)
	General Practitioner services	Medical Visits	0.26 (SE=0.01)	0.24 (SE=0.01)
	Specialist doctor services			

PHBS: Portuguese Household Budget Survey; NRHS: National Representative Health Survey. The information is not completely comparable.

Supplementary Table S3: Financial protection results details: distribution of cases 1-5 (as detailed in Table 2) across population groups defined by income quintiles

Case	1st Quintile		2nd Quintile		3rd Quintile		4th Quintile		5th Quintile	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
1	13.8%	0.01	11.4%	0.01	10.0%	0.01	9.6%	0.01	6.7%	0.01
2	0.0%	NA	40.7%	0.01	88.4%	0.01	90.4%	0.01	93.3%	0.01
3	6.1%	0.005	38.8%	0.01	1.3%	0.002	0.0%	NA	0.0%	NA
4	10.6%	0.01	9.1%	0.01	0.3%	0.001	0.0%	NA	0.0%	NA
5	69.5%	0.01	0.0%	NA	0.0%	NA	0.0%	NA	0.0%	NA

SE: Standard Error; NA: Not Applicable. Source: Portuguese Household Budget Survey[18]

CHAPTER FOUR

DETERMINANTS OF OUT-OF-POCKET PAYMENTS FOR HEALTHCARE IN PORTUGAL

ABSTRACT

Background: The aim of this study is to characterize Out-of-Pocket Payments (OOPP) in healthcare, understand their determinants and identify possible vulnerable groups in Portugal.

Methods: Data collected in the last National Representative Health Survey (2014) were analysed for understanding the distribution of OOPP across income quintiles. Three regressions were estimated using two-part models. Households are the unit of analysis. The dependent variables are: 1) OOPP for visits, laboratory tests and other diagnostic and therapeutic procedures; 2) OOPP for medication; 3) OOPP for treatments. We considered for inclusion as independent variables: geographic controls, demographic characteristics, citizenship, enrolment to voluntary health insurance or in health subsystems, health status of the representative or other member of the family, households' and socio-economic characteristics.

Results: In 2014, 62% of Portuguese households reported OOPP in the previous two weeks, with an average expenditure of €37 (SE=1.30). The probability of incurring OOPP is lower when households are single member, resident in the Madeira or Azores islands, low-income and with no sick member. The same happens when the family representative is older than 80 years, uninsured, low-educated, not European Union citizen or smoker. Households with at least one sick member and whose representative has coverage other than NHS also tend to spend more when incurring OOPP.

Conclusions: Legislation safe-guarding access to healthcare, in particular ambulatory medication, for users with chronic disease and poor health may be improved to enhance more equity in access to healthcare.

Key words: Out-of-Pocket expenditures; Accessibility; healthcare; Portugal.

INTRODUCTION

Background

Currently, in Portugal, three health systems co-exist: the universal National Health System (NHS), mainly financed through general taxation; special health insurance schemes (subsystems) for particular professions or sectors (i.e. civil servants, bank and insurance companies' employees) mainly financed by employers' and employees' contributions; and private Voluntary Health Insurance (VHI) [1]. Around 17% of the population has a subsystem insurance and 26% has a VHI [1].

In 2015, public and private financing contributed for 2/3 and 1/3 of health expenditure, respectively. Since total public revenues highly rely on indirect taxes (42.3%, [2]) and private health expenditure is high, Portugal health expenditure is possibly financed in a regressive form [1]. The majority (80%) of private health expenditure is associated with Out-Of-Pocket Payments (OOPP)[12] or, equivalently, OOPP are responsible for 27% of current health expenditure [4].

In Portugal, a user may incur OOPP because of user-fees in private sector or health subsystems and due to co-payments (or user charges) in the NHS. The payment of insurance premiums or monthly contributions for health subsystems are classified as private health expenditure, but not as OOPP.

OOPP is a major concern in middle income and low income countries [5-8] as well in the USA where health expenditure is mainly privately financed [9,10]. It is important to

[12] The World Health Organization (WHO) defines Out-of-pocket payments as "direct payments made by individuals to health care providers at the time of service use" [3].

remember that OOPP are not negative *per se*: their introduction in the NHS aims to cope with the over-consumption of healthcare due to moral hazard [11,12]. However, OOPP may reduce accessibility to healthcare [13] or endanger the overall redistributive effort of the State. In fact, OOPP link the payments of healthcare services to their utilization, with the potential of deterring users to access healthcare services.

In Portugal, Kronenberg and Barros (2014) [14] studied the incidence of catastrophic healthcare expenditure (CHE): CHE was considered to occur in households whose OOPP were higher than 40% of their capacity to pay (measured as the difference between the subsistence need from the household expenditure). Using data from the Portuguese household budget survey, the authors estimated that the proportion of households experiencing CHE were 7.85% and 5.03% in 2000 and 2005, respectively. They found that the poor and elderly were more vulnerable to CHE. The present study will use data collected in 2014 in the last National Representative Health Survey (NRHS) [15] to explore determinants of OOPP. The distribution of OOPP by income group will be analysed and, as in Kronenberg and Barros, we will search for possible vulnerable groups which may be targeted for public interventions.

Portuguese Legislation

In order to analyse and interpret the results of the determinants of OOPP in Portugal, it is important to globally understand the co-payment rules for users of the NHS. Portuguese legislation regarding co-payment within the NHS contains many exceptions both in terms of services waived from co-payments and in terms of users' eligibility. In general terms, NHS co-payments may occur for: primary care visits; specialist visits; emergency visits;

medical devices; non-urgent transportation and outpatient medical consumption (mainly medication).

In terms of service coverage, as in several countries with NHS, dental care and eye care (eyeglasses and contact lenses) are excluded from the NHS [16]. On the other hand, some services are excluded from any co-payments in particular situations in order to promote accessibility (as non-urgent transportation for users with high disability) or a rational utilization of the healthcare services (emergency visits and the first specialist visit when referred by the general practitioner); or to prevent and reduce negative externalities such as the programs for addictions (alcohol and drugs) and sexually transmitted disease screenings.

In terms of users' eligibility for co-payments, in the NHS, in 2017, roughly 60% [1] of the population was exonerated from co-payments of laboratory tests and other diagnostic and therapeutic procedures and medical visits. Users may be exonerated from co-payments because of[13]: financial hardship[14]; unemployment; pregnancy; being a blood donor or a live donor of cells and tissues; being a refugee or asylum seeker; being a fire-fighter, being 18 or younger; having an high disability (60% or higher); or having a listed disease[15]. At the time of the NRHS 2014, children between 15 and 18 were required to pay for healthcare services, with the exemption of particularly disadvantaged children (with judicial problems, living in communities etc.)[16]

[13] Law decree N.113/2011 and Law decree N. 61/2015.
[14] Households with an average monthly income ≤ 1.5 times the Index of Social Support (Ordinance N. 311-D/2011, of 27th December 2011).
[15] Degenerative and demyelinating neurological diseases, Muscular dystrophy, treatment of chronic pain, chemotherapy for oncological diseases, radiotherapy, mental health, blood clotting protein deficiency, HIV/AIDS, and diabetes.
[16] Official Gazette 1st. series — N. 149 — 5th August 2014.

In practical terms, exemption is automatic only for fire-fighters and users younger than 18. All other categories eligible for exemption must present specific documentation at the moment of contact (asylum seekers and relatives) either at the primary care provider (as pregnant women, users with disability and unemployed) or online (for financial hardship) [17].

Finally, co-payment for prescribed medication varies between 15% and 90% depending on the therapeutic class of the medication[17]. Prescribed medication may be free of charge because of: user's financial hardship, the low disease prevalence (such as ichthyosis, lupus, and haemophilia) or for political considerations such as potential negative externalities or equity issues (HIV, Hepatitis C, Alzheimer)[18].

METHODS

Data

Data were collected in a nationally representative health survey, conducted in Portugal in 2014 [15]. Information was collected either during face-to-face interviews or self-completion of a standardized questionnaire. A stratified random probability method was used to select 22,538 households of which 18,204 completed the questionnaire. Within each household, one individual answered the questionnaire. Proxies were not admitted, therefore only capable persons aged 15 or more answered the questionnaire. We wanted to analyse adults' information only, therefore observation regarding the first age-group (15-19 years old) were excluded.

[17]Official Gazette 1st. series — N. 125 — 30th June 2015.
[18]Law decree N. 97/2015.

The questionnaire included questions on the OOPP for healthcare services used by the household during the preceding two weeks. The OOPP were defined as direct payments for healthcare services including (delayed) fiscal reimbursement. Households were asked to report OOPP by group: a) medical visits (including emergency visits); b) laboratory tests and other diagnostic and therapeutic procedures c) acquisition of medication; d) surgery and other treatment (i.e. dental; physiotherapy); e) other treatments (homeopathy, acupuncture; contact lenses; dermatologic products or nurse treatments). The households' OOPP were adjusted using the OECD-modified equivalent scale [18] in order to account for differences in households' size. In the database, households were classified according to their equivalent monthly income [18] in five quintiles. Information regarding the mean income in each quintile was not made available. Analysis of data was performed taking into account the sampling weights provided by Statistics Portugal [15]. Weights account for the probability of selection of each unit, missing data and were calibrated in order to ensure sample's external validity.

Model

Equivalent OOPP were analysed by group and not as the sum of all OOPP, because we expect to find different determinants as a result of the heterogeneity of the legislation regulating co-payments exemptions. Therefore we estimated regression models for three different dependent variables: 1) OOPP for visits or laboratory tests and other diagnostic and therapeutic procedures, 2) OOPP for medication and 3) OOPP for treatments (any type).

The two-part model (TPM) is a commonly used method for the analysis of health expenditure [19-21], although still an object of some discussion [22-23]. Here, the TPM was preferred to the extended Tobit model because the distribution of OOPP most probably results from a mixture of two densities (two decision moments exist) and because it is more adaptive to skewed data [24]. Additionally, Drukker (2017) [25] showed that even when the Tobit model is a generalization of the two-part model (with a probit first part and a normally distributed second part), the marginal effect of covariates is virtually the same independent of the selected model.

For the first part of the model we tested both the probit and logit models and we selected the best fit according to the Akaike criterion (AIC) [26, 27].

For the second part of the model, we tested different specifications of the generalized linear model: we performed the modified Park test [28] for selecting the family and Pregibon's Link Test [29] for selecting the link function.

The following variables were tested for inclusion in the analysis (in both the first and second part of the model):

- Geographic controls: health region (North, Center; Lisbon and Tagus valley; Alentejo, Algarve or Islands) and low density/high density classification.
- Demographic characteristics: age group and sex of household's representative.
- Citizenship of the representative: Portuguese; European (European Union) or Extra European Union.
- Representative is enrolled in a VHI scheme or in health subsystems.

- Health status of the representative or other member family member: representative reporting activity limitations (absent, some or severe); chronic disease[19]; long term health problems, self-reported health ranking (five levels); or being an informal care giver of a family member (at least once per week). We expect that when the representative declares to be an informal care giver, there is a sick individual in the household. Diabetes was not grouped with other chronic diseases since it is more often waived from co-payment in the NHS.
- Households' characteristics: presence of children, presence of elderly, single person household, number of household members.
- Socio-economic characteristics: households' monthly equivalent income percentile; representative education level (six levels) and his/her job status (five levels).

The inclusion of categorical variables (with 3 or more categories) was decided based on the F-statistic from one-way ANOVA tests. When coefficients of consecutive levels of categorical variables were not significantly different from each other, categorical variables were re-grouped.

[19] Asthma, chronic bronchitis, Acute myocardial infarction, angina, hypertension, stroke, arthritis, back pain; neck pain; diabetes, allergies; hepatic cirrhosis; renal diseases, depression, incontinence.

RESULTS

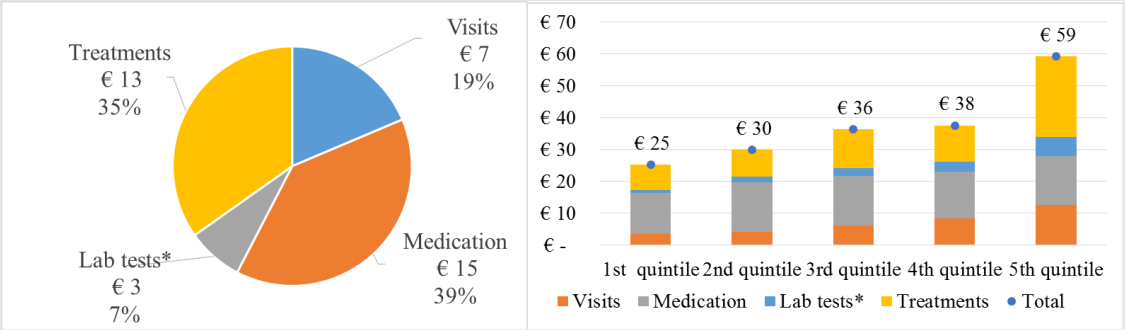
Descriptive statistics

After excluding the respondents aged 19 or less, we had data of 16,876 households, representing 7,909,106 Portuguese people. The proportion of missing answers in each variable of interest (both dependent and independent variables) was always lower than 0.2%. We report descriptive statistics for all variables considered in the analysis in Supplementary Table S1. The average household's equivalent OOPP in the previous two weeks was of €37.91 (SE=1.30), with households incurring a positive OOPP reporting on average an expenditure of €60.70 (SE=2.01). In Portugal, this corresponds to 11.4% of the mean household equivalent income in the last two weeks [30].

This is because the 37.5% of households reported no OOPP (for any reason) in the previous two weeks. Nevertheless, this proportion significantly varied among OOPP groups: proportion of households with inexistent OOPP for laboratory test and diagnostic procedures is as high as 87.6%, while only 45.0% declared no expenses for medication (more details are reported in Supplementary Table S1).

In Figure 1, we represent the OOPP by group and income quintile.

Figure 3: On the left, overall Out-of-Pocket Payments by group. On the right, Out-of-Pocket Payments by group and income quintile.



*Laboratory tests and other diagnostic and therapeutic procedures. Out-of-Pocket payments reported for the previous two weeks.

In Figure 1 it can be noticed that the majority of OOPP is associated to medication and that treatments are responsible for a larger proportion of OOPP than the sum of both visits and laboratory test expenses. This result together with the knowledge that only 12.4% of households incur OOPP for treatments, is possible because the expenses for treatments are very large when occurring (on average €94.33, SE=7.64). We note that the treatment expenses include, among others, dental care, physiotherapy and eye care, services that may be expensive when occurring.

Inferential statistics

In the first part of the model the logit model was always preferred to the probit while in the second part, the gamma distribution with a logistic link function was the best fit for all three regressions. The regressions' results are presented in Table 1.

Table 1: Two-part model regressions' results. Logistic results are presented in odd-ratios while for Generalized Linear Model, beta coefficients are shown. Last column presents the overall marginal effect (the discrete change from the base of the categorical variable)

	OOPP Visits/lab tests[a]			*OOPP Medication*			*OOPP Treatments*		
	Logit	**GLM**	**Marginal Effect**	**Logit**	**GLM**	**Marginal Effect**	**Logit**	**GLM**	**Marginal Effect**
	Odd Ratios	**Beta**		**Odd Ratios**	**Beta**		**Odd Ratios**	**Beta**	
ISLANDS	0.68***	0.29***	0.25	0.81***	0.07*	-0.27	0.72***	0.29*	0.21
INSURED									
None	Baseline	Baseline					Baseline		
VHI only	1.96***	0.27**	7.74***				1.40***		1.16**
Health subsystem only	1.70***	0.044	3.74***				1.47**		4.41***
VHI+ Health subsystem	2.74***	0.31*	9.64***				2.11***		5.65***
EXTRA EUROPEAN	0.52*		-4.20*	0.61*		-3.00*			
SMOKER	0.78**		-1.59*	0.85*		-1.02*	0.73**		-3.21**
AGED 80+	0.80*		-3.31*	0.74**	0.16*	0.54			
INFORMAL CARE GIVER	1.26**	0.27***	3.98***	1.39***	0.12**	3.88***	1.29***		2.69**
LONG TERM HEALTH PROBLEM				1.22*	0.13*	3.76**		0.41**	4.91**
CHRONIC DISEASE REPORTED	1.35***		1.91***	1.45***		1.80***			
DIABETES				1.31**	0.15***	4.01***			
SELF RATE HEALTH STATUS									
Good/Very Good				Baseline	Baseline	Baseline			
Reasonable				1.25***	0.16**	3.48***			
Bad or very bad				1.47***	0.30***	7.24***			
ACTIVITY LIMITATION									
No limitations				Baseline		Baseline	Baseline		Baseline
Some limitations				1.25***		1.33**	1.21*		1.95*

Severe limitations				1.59***		2.81***	1.50**		4.48**
OLD_MEMBER				1.68***	0.22***	6.58***			
LIVING_ALONE	0.48***	0.44***	-0.61	0.48***	0.21***	-1.23*	0.51***		-6.85***
CHILDREN LIVING IN THE HOUSE								-0.30**	-3.62**
EQUIVALENT INCOME									
1st quintile		Baseline	Baseline		Baseline	Baseline			
2nd quintile		0.08	0.58		0.07	0.58			
3rd quintile		0.15	1.23		0.17***	2.40***			
4th quintile		0.22**	1.82**		0.23***	3.39***			
5th quintile		0.44***	4.12***		0.32***	4.95***			
YEARS OF EDUCATION									
Less than 3 years	Baseline		Baseline	Baseline		Baseline	Baseline		Baseline
3 to 12 years	1.38***		2.01***	1.21***		1.12***	1.85***		6.37***
Over 12 years	1.85***		4.11***	1.50***		2.42***	2.19***		8.66***
Constant	0.23***	3.12***		0.57***	3.42***		0.09***	4.36***	

* For p<.05, ** for p<.01, and *** for p<.001; OOPP: Out-of-Pocket treatments; [a]laboratory tests and other diagnostic and therapeutic procedures

The only geographical control which was found significant is the variable *ISLAND* which equals one when the household lives in Madeira or Azores autonomous regions, where there is no NHS. Other health regions as well as the classification of the territory as highly populated or not highly populated were not found to be significant in any regression (and were therefore excluded). Households living in the islands incur in OOPP with lower probability, but when they do, they spend relatively more than households living on the mainland.

We found that when the household's representative has a VHI, or he/she is covered by a health subsystem or both, the probability of incurring a private expenditure for visits, laboratory tests and treatment increases. Having extra coverage also increases the expected expenditure for visits and laboratory tests when expenditure is positive. In line with the fact that private insurances do not usually cover outpatient drug expenditure, the presence of additional insurance does not significantly predict OOPP for medication.

When the respondent is a citizen of a non-European Union country, his/her family has 48% and 39% lower probability of spending money for visits and medication, respectively. This result may reflect either a higher difficulty in accessing healthcare or a different cultural relationship with the healthcare system.

The variable SMOKER is associated with a lower probability of health expenditure, which may result from an overall decision of lower investment in health. We note that the inpatient healthcare is fully covered by the NHS.

At least one of the variables capturing the health status of the representative or other family member (representative being an informal care giver of a family member, having a chronic disease, diabetes, poor consideration of his/her health, reporting activity limitations or long term health problem) is associated with a significantly higher probability of incurring an expense, with an overall marginal

effect consistently positive. This means that users with poorer reported health incur higher OOPP in any dimension.

Another interesting result regards the diabetic population. The dummy variable DIABETES is not significant either for predicting treatments nor visits expenditure. This may result from the higher financial protection legislation reserved for these patients. Nevertheless diabetic patients still have higher probability of incurring expenditure for medication and are expected to have higher medication expenditure *ceteris paribus* compared to non-diabetic population (€4 in two weeks).

Additionally, households with an elderly member (65 years or older) incur higher expenditure for medication. On the contrary, single person households are less likely to incur expenses, but when it happens they spend more. Having children in the household does not impact the OOPP except for treatments. This may be because children are more financially protected by the legislation and need less treatments than the average adult.

Finally, in line with mainstream health economics [31], we find that more educated individuals report higher healthcare expenditure. Surprisingly, income is not significant in predicting OOPP for treatments. Its contribution for other OOPP is positive, as expected.

DISCUSSION

In 2014, 62% of Portuguese households reported out-of-pocket payments in the previous two weeks, with an average expenditure of €38 (SE=1.30).

The probability of incurring OOPP is lower when households are single person households, resident in the Madeira or Azores islands or with no sick member. The same happens when the family representative is older than 80 years, uninsured, low-educated, extra EU or smoker. All these circumstances, except for single person households, may reflect a lower accessibility to healthcare or decision of lower investment in health. Instead, consistently with findings from other studies [34-38], expenditure is higher when the household has an elderly member.

The fact that education of the representative is significant only in the first part of the regression may be explained by a higher awareness of the functioning of the healthcare system including the co-payment schemes and their exceptions.

Low-income families spend relatively less when incurring OOPP and this is probably because they are eligible for co-payments exemptions. On the other hand, households with at least one sick member and whose representative has more than only NHS coverage also tend to spend more when incurring OOPP. We were surprised that the unemployment dummy variable was not significant in any regression, since unemployed people are eligible for co-payments exemptions.

We found that households reporting health problems are particularly penalized in terms of health expenditure for medication. This result is in line with Kronenberg and Barros (2014) [14,39], who, using 2000 and 2005 Portuguese data, found that the elderly population was more likely to incur catastrophic healthcare expenditure probably because they were more prone to becoming sick. A higher protection for individuals reporting health problems should be considered by policy makers. We also found that the largest source of OOPP was associated to medication (39%), while Kronenberg and Barros (2014) found that expenditure in pharmaceuticals was higher than all other

healthcare expenditures together (65%) [14]. This difference may be due to the time horizon of the report (two weeks *versus* mostly one year) and recall bias.

This study has both an advantage and a disadvantage compared to other studies analysing the determinants of financial burden in Portugal [14,39] . From one side, this database has richer information regarding health determinants of OOPP, from the other we had to analyse all OOPP and not only OOPP endangering the household ability to pay. In fact OOPP are not negative *per se*, but they may undermine access to healthcare or the overall redistributive role of the State. The analysis of the determinants of OOPP should help identify groups that are unfairly paying more than other groups.

This study has also some limitations.

As always, national health surveys fail to capture all population, excluding for instance, student living temporarily in another residence, homeless, hospitalized or nursing home population [40].

Additionally, we were not able to assess the health status of all household members, since only one individual for each household was answering the questionnaire, reporting only about his/her own health status. We attempted to capture the presence of other sick members in the household by introducing the informal care giver variable and a dummy variable indicating whether there is at least an elderly member in the household.

Additionally, it should be kept in mind that, as in the majority of health surveys, health conditions were self-reported without a medical assessment. Reporting bias is a concrete issue in these cases [34,35].

We consider that the questions regarding OOPP were not ideal: it was asked to report all payments including fiscal reimbursement, although fiscal reimbursement should not be considered in OOPP. At the time of the data collection, households were entitled to the reimbursement of 15% of overall health expenditure (excluding-over-the-counter medicines) up to a yearly limit of €1,000.

CONCLSUSION

We found that in 2014 the majority of Portuguese households reported out-of-pocket payments in the previous two weeks. Households reporting health problems predict higher OOPP. This is particularly true when analysing expenditure for medication. Results suggest that legislation safe-guarding access to ambulatory medication for users with chronic disease and poor health may be improved to enhance more equity in access to healthcare.

REFERENCES

1. Simões, J., Augusto, G.F., Fronteira, I., Hernández-Quevedo, C. Portugal: Health system review. Health Systems in Transition. 19(2):1–184 (2017).

2. INE (2016). Estatística das Receitas Fiscais, 1995–2015 [Fiscal revenue Statistics, 1995–2015]. Lisbon, INE-Statistics Portugal.

3. World Health Organization (WHO). Out-of-pocket payments, user fees and catastrophic expenditure. http://www.who.int/health_financing/topics/financial-protection/out-of-pocket-payments/en/ (2017). Accessed 22 Jan 2018.

4. OCDE. Health Spending. https://data.oecd.org/healthres/health-spending.htm. (2017). Accessed 22 January 2018.

5. Yardim, M.S., Cilingiroglu, N., Yardim, N. Catastrophic health expenditure and impoverishment in Turkey. Health Policy. 94:26–33. (2010).

6. Wagstaff, A., van Doorslaer, E. Catastrophe and impoverishment in paying for health care: with applications to Vietnam 1993–1998. Health Economics. 12:921–934. (2003).

7. Amaya-Lara, J.L. Catastrophic expenditure due to out-of-pocket health payments and its determinants in Colombian households. Int J Equity Health. 15(1):182 (2016).

8. Brinda, E.M., Kowal, P., Attermann, J., Enemark, U.: Health service use, out-of-pocket payments and catastrophic health expenditure among older people in India: the WHO Study on global AGEing and adult health (SAGE). J Epidemiol Community Health. 69(5):489-94. (2015)

9. Waters, H.R., Anderson, G.F., Mays, J.: Measuring financial protection in health in the United States. Health Policy.;69:339–349. (2004).

10. Himmelstein, D.U., Warren, E., Thorne, D., Woolhandler, S.: Illness and injury as contributors to bankruptcy. Health Affairs (Millwood). (2005).

11. Zeckhauser, R.J.: Medical insurance: A case study of the tradeoff between risk spreading and appropriate incentives. J. Econ. Theory 2(1), 10–26. (1970).

12. Drummond, M., Towse, A.: Is it time to reconsider the role of patient co-payments for pharmaceuticals in Europe? Eur J Health Econ. 13(1):1-5. (2012).

13. Manning, W.G., Newhouse, J.P., Duan, N., et al.: Health Insurance and the Demand for Medical Care. The RAND Corporation, Santa Monica, CA. (1988).

14. Kronenberg, C., Barros, P.P.: Catastrophic healthcare expenditure - drivers and protection: the Portuguese case. Health Policy. 115(1):44-51. (2014).

15. Statistics Portugal and Instituto Nacional de Saúde Doutor Ricardo Jorge. Inquérito Nacional de Saúde 2014 [National Health Survey].

16. Paris, V., Hewlett, E., Auraaen, A., Alexa, J., Simon L.: Health care coverage in OECD countries in 2012. *OECD Health Working Papers*, 2016. No. 88, OECD Publishing, Paris.

17. ACSS: Revisão de categorias de isenção e atualização de valores das taxas moderadoras. http://www.acss.min-saude.pt/wp-content/uploads/2016/09/FAQ_taxas_moderadoras_Dezembro2017-1.pdf. (2017) Accessed 22 Jan 2018.

18. Hagenaars A.J.M., De Vos, K, Zaidi, A.: Poverty statistics in the late 1980s: Research based on micro-data. Luxembourg: Office for official publications of the European Union. 1994.

19. Duan, N., Manninf, W.G., Morris, C.N.: Choosing between the sample-selection model and the multi-part model. Journal of Business & Economic Statistics, 2(3): 283-289. (1984).

20. Dormont, B., Grignon, M., Huber, H.: Health expenditure growth: reassessing the threat of ageing. Health Econ. 15(9):947-63 (2006).

21. Mihaylova, B., Briggs, A., O'Hagan, A., Thompson, S.G.: Review of statistical methods for analysing healthcare resources and costs. Health Econ. 20(8):897-916 (2011)

22. Buntin M.B., Zaslavsky A.M.: Too much ado about two-part models and transformation? Comparing methods of modeling Medicare expenditures. J Health Econ. 23(3):525-42. (2004).

23. Deb, P., Trivedi, P.K.: The structure of demand for health care: latent class versus two-part models. J Health Econ. 21(4):601-25. (2002).

24. Deb, P., Norton, E.C., Manning WG. Health Econometrics Using Stata. Stata Press. (2017).

25. Drukker, D.M.: Two-part models are robust to endogenous selection. Economics Letters. 152(C):71-72. (2017).

26. Akaike, H.: Information theory and an extension of the maximum likelihood principle. In B. N. Petrov and F. Csaki (Eds.), ` Proceedings of the Second International Symposium on Information Theory, pp. 267–281. Budapest: Akademiai Kiad ´ o. Reprinted in ´ Breakthroughs in Statistics, vol. 1, pp. 610-624, eds. Kotz, S. and Johnson, N. L., 1992, New York: Springer .(2017).

27. Chen, G. Tsurumi, H.: Probit and logit model selection. Communications in Statistics - Theory and Methods. 40, 159-175. (2010).

28. Park, R.E.: Estimation with heteroscedastic error terms. Econometrica 34:888 (1966)

29. Pregibon D. Goodness of Link Tests for Generalized Linear Models. Journal of the Royal Statistical Society. Series C (Applied Statistics). 29(1): 15-23, 14. (1980).

30. Statistics of Portugal. Household Budget Survey/HBS series. Published online 17 July (2017).

31. Grossman, M.: On the Concept of Health Capital and the Demand for Health. Journal of Political Economy, 80 (2):223-255. (1972).

32. Anthony, B. Atkinson. Inequality What Can Be Done? First Edition, Harvard University Press (2015).

33. Zhu, K., McKnight, B., Stergachis, A., Daling, J.R., Levine, R.S.: Comparison of self-report data and medical records data: results from a case-control study on prostate cancer. Int J Epidemiol. 28(3):409-17. (1999).

34. Sarker AR, Mahumud RA, Sultana M, Ahmed S, Ahmed W, Khan JA. The impact of age and sex on healthcare expenditure of households in Bangladesh. Springerplus 2014;3: 435.

35. Li Y, Wu Q, Xu L, Legge D, Hao Y, Gao L, et al. Factors affecting catastrophic health expenditure and impoverishment from medical expenses in China: policy implications of universal health insurance. Bull World Health Organ 2012;90(9):664-671.

36. Jiang C, Ma J, Zhang X, Luo W. Measuring financial protection for health in families with chronic conditions in rural China. BMC Public Health 2012;12: 988.

37. Shi W, Chongsuvivatwong V, Geater A, Zhang J, Zhang H, Brombal D. Effect of household and village characteristics on financial catastrophe and impoverishment due to health care spending in western and central rural China: a multilevel analysis. Health Res Policy Syst 2011;9: 16.

38. Alemayehu B, Warner KE. The lifetime distribution of health care costs. Health Serv Res 2004;39(3):627-642.

39. Quintal C, Lopes J. Equity in health care financing in Portugal: findings from the Household Budget Survey 2010/2011. Health Econ Policy Law. Jul;11(3):233-52. (2016).

40. Dowd J.B., Todd, M.: Does self-reported health bias the measurement of health inequalities in U.S. adults? Evidence using anchoring vignettes from the Health and Retirement Study. J Gerontol B Psychol Sci Soc Sci. 66(4):478-89. (2011).

SUPPLEMENTARY MATERIAL

Supplementary Table S1: Resume of Variables of interest in the database

Variable	Classes	Value
Geographic characteristics		
Health region	North	34.45%
	Centre	16.53%
	Lisbon and Tagus Valley	34.87%
	Alentejo	5.00%
	Algarve	4.31%
	Madeira Autonomous Region	2.33%
	Azores Autonomous Region	2.50%
Population density	High	43.19%
	Medium	29.82%
	Low	26.99%
Respondent's characteristics		
Female respondents	Yes	53.90%
Age groups	19-29	13.06%
	30-39	17.45%
	40-49	18.66%
	50-59	17.62%
	60-69	14.83%
	70-79	11.13%
	80+	7.24%
Extra European Union citizenship	Yes	1.61%
Socio-economic characteristics		
Education Level	Up to 6 years	46.08%
	between 7 and 12 years	35.04%
	More than 12 years	18.88%
Employment Status	Employed	49.65%
	Unemployed	13.08%
	Student	3.33%
	Retired	26.34%
	Permanently unable to work	1.17%
	Home maker	5.59%
	Other inactivity	0.84%
Voluntary health insurance	Yes	19.51%
Health status of the representative or other member of the family		

Chronic disease (Except Diabetes)	Yes	61.80%
Diabetes	Yes	9.96%
Self-reported health status	Very good	0.03%
	Good	11.64%
	Reasonable	36.94%
	Bad	37.02%
	Very bad	10.80%
Long-term health problem	Yes	41.30%
Health Limitations	None	67%
	Not Severe	24%
	Severe	9%
Informal Health Giver	Yes	10.98%
Out-of-Pocket expenditures (2 weeks)		
Equivalent Out-of-Pocket Payments for visits	Inexistent	74.9%
	When Positive (in €; SE)	28.15;0.83
Equivalent Out-of-Pocket Payments for medication	Inexistent	45.0%
	When Positive (in €; SE)	26.87;0.46
Equivalent Out-of-Pocket Payment for laboratory tests and diagnostic procedures	Inexistent	87.6%
	When Positive (in €; SE)	23.26;1.28
Equivalent Out-of-Pocket Payment for treatments	Inexistent	86.0%
	When Positive (in €; SE)	94.33;7.64
Equivalent Out-of-Pocket Payment for any reason	Inexistent	37.5%
	When Positive (in €; SE)	60.96;2.01
Household characteristics		
Household size	One	10.92%
	Two	30.73%
	Three	28.84%
	Four	21.10%
	Five or more	8.41%
Children In the household	Yes	26%
Family member Aged 65+	Yes	34%
Living alone	Yes	11%

CONCLUSION

In this original work, we studied three different aspects of access to healthcare: 1) geographical barriers (e.g. geographical accessibility); 2) organizational barriers; and 3) financial barriers. These analyses are empirical and are restricted to specific barriers that may exist in the Portuguese context.

Geographical accessibility was analysed in the context of Acute Myocardial Infarction (AMI) specialised emergency units in Portugal *(via verde coronária)*.

Here, we found no significant association between in-hospital mortality and the time of travel between patients' residence and the closest AMI-VV hospital, or whether the closest hospital had the AMI-VV protocol or not. These results suggest that in a large Portuguese Region (Lisbon and Tagus Valley) there is an equitable distribution of service across the territory. Assuming that need is independent from the distribution across the region, this analysis provides some insights regarding horizontal equity in access to healthcare with patients in equal need having equal health outcomes (in-hospital mortality).

Nevertheless we believe that further research is needed to assess the impact of the *via verde* program on the health outcomes of the Portuguese population experiencing an AMI. For instance, the impact that distance may have on long-term consequences of AMI should be assessed in future research.

The possible existence of organizational barriers was explored in terms of variation of in-hospital mortality and variation in treatment for AMI between weekdays and weekends. Specifically, we studied whether being admitted during weekends or public holidays significantly predicts higher

probability of death and lower probability of prompt surgical intervention after controlling for a range of confounding mechanisms which may also influence mortality rates.

It was found that the in-hospital mortality of AMI episodes via emergency units in Portuguese national hospitals is not significantly higher for admission on weekends or public holidays than for admissions on weekdays. Still, patients admitted on weekends had a lower probability of undergoing invasive cardiac surgery in the day of or the day after admission. The delay in performing a cardiac procedure for patients admitted during weekends did not lead to significantly worse outcomes in terms of mortality.

We found that outcomes, measured in terms of in-hospital mortality, did not vary within a group with the same need (all experiencing AMI). Therefore, we did not find evidence of horizontal inequity due to organizational barriers in this specific situation.

The last part of my contribution to the literature focuses on financial barriers to healthcare. In particular, in the last two chapters, different aspects of out-of-pocket payments (OOPP) were analysed in the Portuguese context.

We found that in 2015 the majority of Portuguese households reported OOPP in the previous two weeks. Medication was the largest contributor to OOPP. Overall, OOPP were found to be regressive, with richer families spending on average proportionally less than poorer families. OOPP for medication are the most unequally distributed across income groups. The proportion of households who became impoverished as a result of OOPP, or who paid OOPP while already being impoverished was found to be relevant, although a normative reference for comparison of the results does not exist. Additionally, many Portuguese claim that they are reducing utilization of healthcare services (dental care, medical visits, prescribed medication and mental healthcare) due to financial constraints. Additionally, we found that households reporting health problems predict higher OOPP. This is

particularly true when analysing expenditure for medication. It does not seem ‘fair’ that being sicker is associated with higher OOPP.

Overall, the last two chapters of this work highlight the issue of financial barriers to healthcare in a country with a National Health System. Results suggest that legislation safe-guarding access to outpatient medication for users with chronic disease and poor health may enhance more equity in access to healthcare by reducing financial barriers.

In conclusion, we found evidence supporting the existence of financial barriers. However, in the context of the specific research questions, no evidence for organizational and geographical barriers was found.

ACKNOWLEDGEMENTS

I gratefully acknowledge several formal and informal collaborators throughout the course of my thesis.

The article “Does acute myocardial infarction kill more people on weekends? Analysis of in-hospital mortality rates for weekend admissions in Portugal” was written in collaboration with Raquel Ascenção M.D. and Prof. Nicoletta Rosati. Raquel Ascenção is a colleague as well as a medical doctor and an excellent researcher. She helped by providing clinical insight regarding the functioning of the emergency room in Portugal and the treatment of AMI. During this study Nicoletta Rosati was my PhD supervisor at ISEG. She provided valuable guidance regarding the ‘weekend effect’ project and related work. However since 2018 she is no longer affiliated with ISEG for personal reasons which made it impossible for her to officially continue as my supervisor.

Prof. Pedro Cabral taught me how to work with geographical information (although much more could be learned). I had the opportunity to join his class at NOVA Information Management School (IMS) in the second semester of the elective year 2016/2017. He supervised and collaborated in the project of *via verde* in which I used geographical information to compute the main variable of interest (distance between the patients’ residence and the closest hospital with *via verde*).

Finally, I was able to count on the supervision of Prof. Miguel St. Aubyn who replaced Prof. Nicoletta Rosati as my supervisor in mid-2017. He supervised my most recent work.
I am also grateful to my friends Jacob MacDonald and Robert Hill who patiently helped by editing and proofreading my work.